IV GENUS *METAPENAEUS* WOOD-MASON & ALCOCK 1981

M.J. George

Species belonging to this genus are distributed throughout the Indo-Pacific region. In a recent revision of the genus Racek & Dall (1965) raised the number of determinable species included in the genus to 22. Since then 2 more new species have been described from Indian waters, raising the number to 24. Of these, 10 species have been recorded to occur in Indian waters. They are *Metapenaeus dobsoni* (Miers), *M. monoceros* (Fabricius), *M. affinis* (M. Edwards), *M. brevicornis* (M. Edwards), *M. ensis* (De Haan), *M. Iysianassa* (de Man), *M. burkenroadi* Kubo, *M. stebbingi* (Nobili), *M. kutchensis* George *et al*., and *M. alcocki* George and Rao. Among these, those species which are commercially important are dealt with in detail below with reference to their biology and fishery.

1. *METAPENAEUS DOBSONI* (MIERS 1878)

Common name

On the south west coast of India in the vernacular language the name "thelly chemmeen" is applied to the smaller sizes caught from the estuaries and backwaters and "Poovaalan or Kadal chemmeen" to the bigger sizes caught from the sea. On the north east coast it is known as "chingri". On the south east coast in Tamil Nadu it is known as "era".

Diagnostic features

Body lightly tomentose in patches. Rostrum extending a little beyond the tip of the antennular peduncle, with 8 or 9 dorsal teeth and having a well marked double curve. Anterolateral angles of the carapace without spine. The post-rostral crest fades away well in front of the posterior border of the carapace. The antennal spine is not very strong and not continued backward as a strong ridge, so that the post-antennular sulcus is not so deep in *M. monoceros*. The anterior abdominal terga are not, or only most obscurely carinated. (Fig. 7a-c).

The 5th abdominal somite about 2/3 length of the 6th, which is a little shorter than the telson. The telson shorter than the endopod of the uropod and without lateral marginal spines. The inner antennular flagellum longer than the outer, exceeding its peduncle in length.

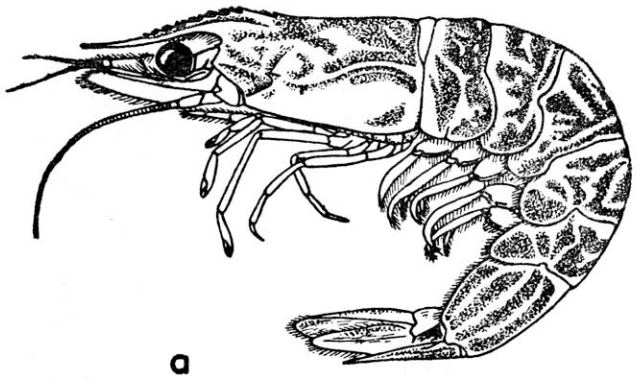
All the legs are ciliated and the chelae weak. Strong spines present on the basis of all 3 pairs of chelipeds. In the male the basial spine on the 3rd pair is a long barb projecting considerably beyond the base of the merus. The last pair of thoracic legs do not nearly reach the middle of the antennal scale; in the male owing to a twist in the ischium, the large tooth (completing) the notch at the proximal end of the merus is turned forwards and outwards; anterior to this tooth there may be a second smaller tooth, but no row of denticles. In the adult female the last pair of thoracic legs is generally represented by a coxa to which is articulated a horny stump. No exopod on the 5th pair of legs.

The petasma (Fig. 7b) is quite symmetrical. In the adult it consists of 2 rigid segments tightly folded in all their length, interlocked all along their anterior margin, and in close apposition along a great part of their posterior margin so as to form a compressed tube. Distally the tube ends in a pair of simple distomedian spouts; and where the spouts originate there are 4 papillae or short filaments, 2 anterior and 2 posterior.

The thelycum (Fig. 7c) consists of a broad concave median tongue, more or less ensheathed posteriorly in a salient horse-shoe shaped process formed by the union of the lateral lobes of the organ itself. In impregnated females the thelycum is obscured by a pair of white conjoined pads which have a broadly triangular outline, tapering from a broad posterior base to a bluntly rounded anterior tip.

The species rarely exceeds 125 mm in total length.

Colouration:- In life it is semi-transparent ; the pigment spots scattered on the carapce and abdomen are for the most part reddish, but tend to a browner shade on the rostrum and to a greenish tone on the posterior edges of each of the abdominal pleura. The antennules, antennae and antennal scales are dotted with red. There is a double row of reddish spots on the telson, the margins being greenish. Both uropods are red at the tip,



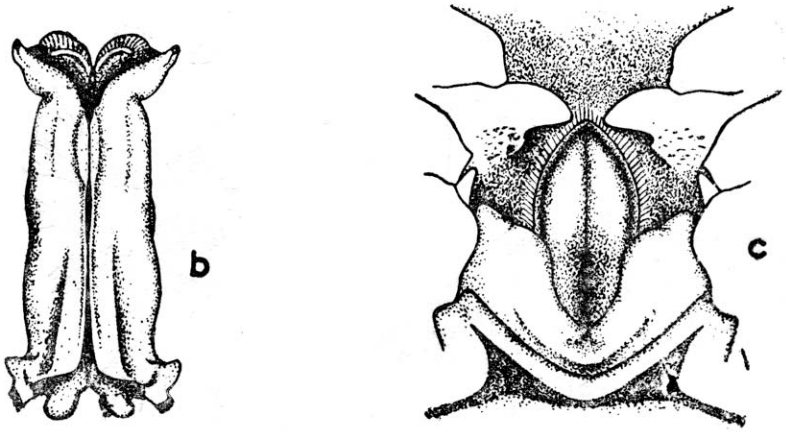


Fig. 7. a. *Metapenaeus dobsoni* (Miers);
b. Petasma; c. Thelycum.

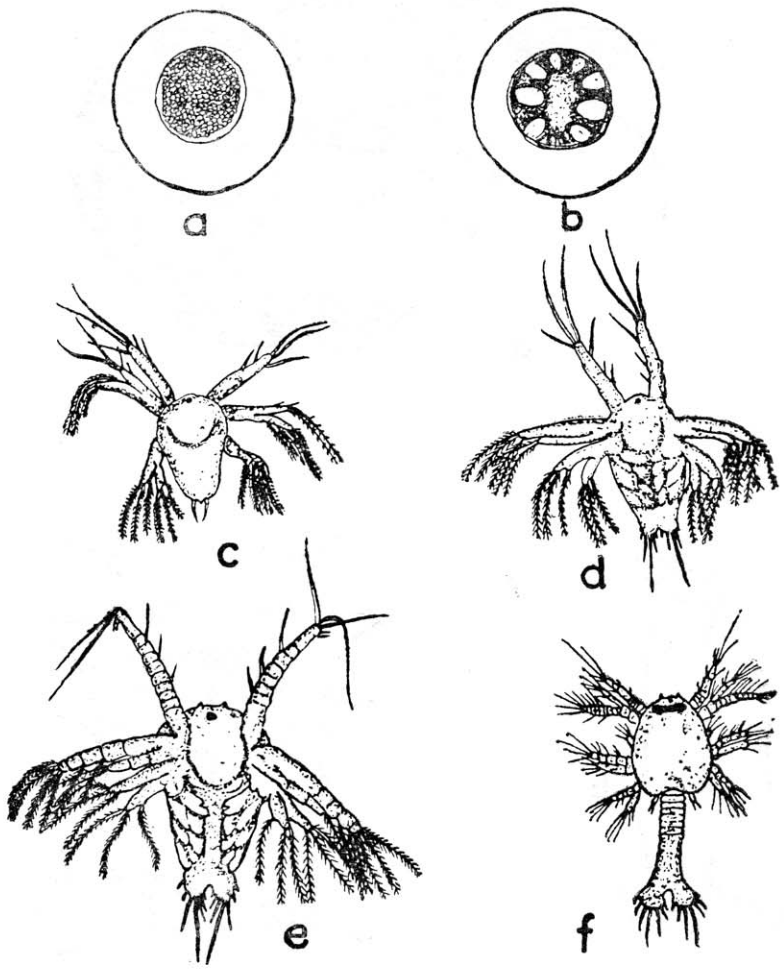


Fig. 8. *M. dobsoni* a–b. egg; c. Nauplius I;
d. Nauplius II; e. Nauplius III; f Protozoea I.

the exopods being also bordered with red externally and green internally.

Distribution

General distribution:- The species is distributed from Indian waters through Malaysia and Indonesia to Philippine Islands. According to the land and water areas code given by Holthuis & Rosa (1965) the distribution of the species in land areas is in 423, 424, 433, 434 and 437. In water areas it is distributed in the regions ISW and ISEW. It is found in brackishwater as well as marine environments.

In Indian waters the species is present in the juvenile stages in most of the estuaries and backwaters along the coastline and the adults in inshore areas up to 20 fathoms depth with muddy bottom. It is more common along the south west coast of India, where it contributes to a major fishery.

Differential distribution of stages:- The eggs and larvae of this species are plenty at the surface and near the bottom from depths ranging between 2 to 15 fathoms in the inshore waters near estuaries throughout the coastline north of Quilon and south of Mangalore on the south west coast of India. The period of occurrence of these eggs and larvae is fairly long from September to April.

The early postlarval stages migrate into the various estuaries and backwaters along the Indian coast and the juvenile stages are abundant in these environments throughout the year and contribute to a good fishery. In the Cochin backwaters this migration commences at the late mysis stages and quite a large proportion passes into brackishwater areas before they reach about 5 mm length. Fairly large numbers of these postlarvae are observed in the backwater plankton in almost all the months of the year with two peaks, one in the months June through August and the other in November. Juveniles are present in the backwaters throughout the year and support a valuable backwater prawn fishery in the areas.

Adults are present in the inshore areas including the mud banks. They are present in slightly deeper regions where they support the trawl fishery.

Life history

Eggs and larvae :- The most highly developed ovarian eggs measure 0.32 mm. Eggs in different stages of development shown in fig. 8 a-b are given by Menon (1951). They measure from 0.35 to 0.44 mm in size. Both the early embryos and the fully developed nauplii do not fill the eggs completely, a wide space known as the perivitelline space being left around them. The embryo is closely invested with a thin embryonic membrane which rapture later and the nauplius comes to lie within the egg membrane with appendages partly straightened out so as to occupy the entire space inside. Once the fully developed nauplii are seen inside the eggs hatching takes place in one or two hours.

The eggs are shed in the sea water and they hatch within 12 to 18 hours after spawning. The larval stages are plannktonic and there is no evidence of the adults caring for the eggs or young ones. The 1st nauplius stage (fig. 8c) hatching out of the egg has a pear-shaped unsegmented body with a pair of setae at the posterior end, a median eye at the anterior end and 3 pairs of appendages of which the anterior one is uniramous and the other two biramous. This nauplius undergoes two moults and the last nauplius stage shows considerable difference (Fig. 8a&c). At the posterior end of the body there is bifurcate telson bearing 7 pairs of spines of unequal length. Rudiments of 4 pairs of appendages are developed behind the 3 pairs of the previous stages. The nauplius phase in the larval history lasts from 24 to 36 hours. The third nauplius moults into the protozoea which has a dorsal carapace in the anterior part of the body (fig. 8f). All segments of the thorax are differentiated behind the appendages of the last nauplius. The abdomen remains unsegmented and terminated in the caudal fork with spine formula 1+7. Both mouth and anus are developed and the larvae feeds actively. There are two more protozoea stages (Fig. 9a&b). In the 3rd stage all the abdominal segments are formed and the 6th segment possesses the uropods. The abdominal segments develop median dorsal and lateral spines. A well developed rostrum is present at the front end of the carapace and a pair of supraorbital spines also is present. Stalked eye with dark cornea are seen projecting from the carapace. The antenna is well developed and biramous carrying feathery setae and this

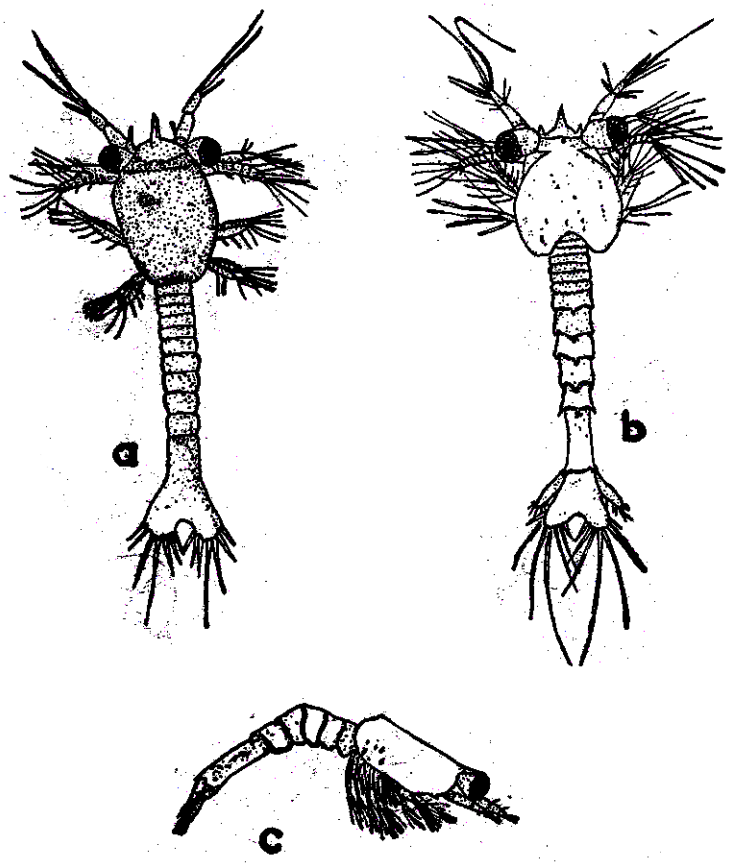


Fig. 9. *M. dobsoni* a. Protozoea II; b. Protozoea III; c. Mysis I.

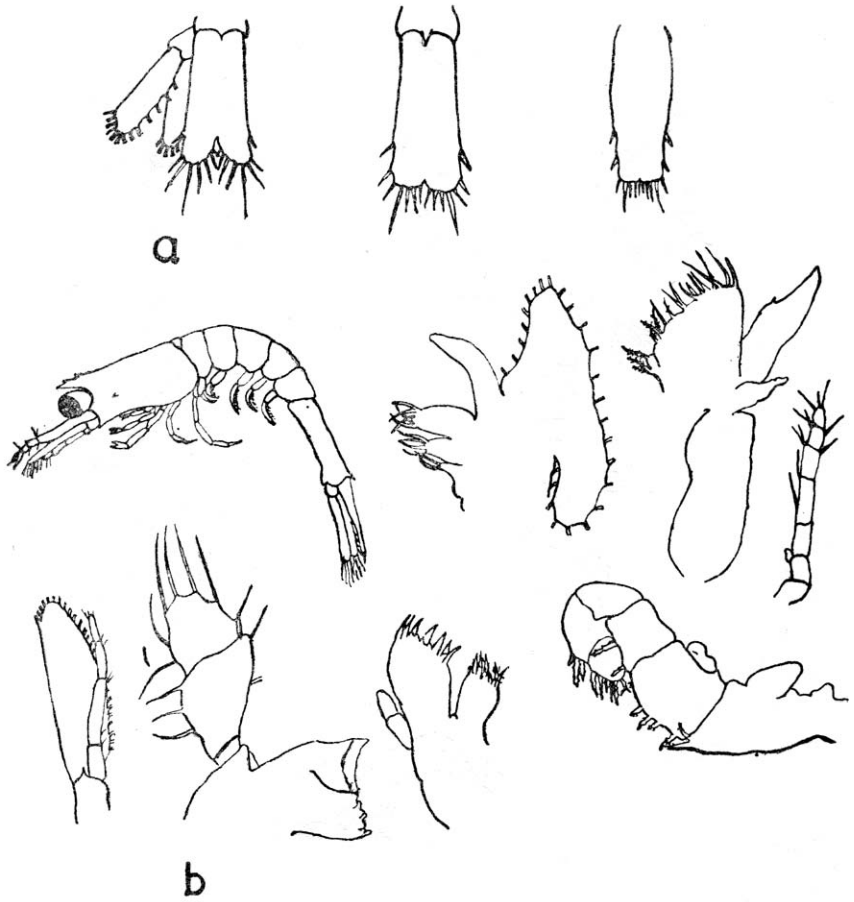


Fig. 10. *M. dobsoni* a. Telson of Mysis stages I to III; b. Post larva I and appendages.

is merely used in locomation. The 3rd protozoea undergoes a moult and changes into the 1st mysis or zoea stage (fig. 9c). The larva now has an elongated somewhat laterally compressed body more or less similar to that of the adult prawn. There are 3 mysis stages during the moults of which exopodites tipped with feathery setae are developed on all the thoracic legs and pleopods appear on the abdominal segments. The forked telson of the protozoea changes into an elongated flat plate with almost parallel sides and a deep cleft on the posterior margin. This cleft gets less pronounced and disappears in the last zoea stage (fig. 10a). Gill rudiments also develop at this time. When the last zoea stage metamorphoses into the first postlarval stage 3 or 4 weeks after spawning the exopodites on the thoracic legs get reduced in size or disappear and setae are developed on the pleopods which become functional as the pricipal swimming organ, although remaining uniramous. A conspicuous hepatic spine appears on each side of the carapace. The cleft on the posterior margin of the telson disappears completely and spines develop on either margin of the posterior half which is narrower (fig. 10b). This postlarva undergoes a series of moults occurring at intervals of about 2 days at first and subsequently becoming irregular between 3 to 6 days. Approximately 7 weeks are taken by the 1st postlarva to reach the 13th stage in which the rostrum with the full complements of dentation, the rudiments of the secondary sex characters etc. are present.

The larvae at nauplius stages do not feed, nutriments being provided by the yolk material inside the body. The protozoea, however, feeds actively on diatoms and other forms of phytoplankton mixed with microscopic animal forms. Mysis and earlier postlarval stages also thrive well on plankton containing a good proportion of algal constituents.

Nutrition and growth:- The food in general consists of varying amounts of organic matter mixed with sand and mud. Fragments or entire bodies of small animals and algae including diatoms compose the organic matter. The proportion of vegetable constituents has been found to be less in the larger individuals, as shown by the examination of stomach contents of prawns of varying sizes. The animal matter mostly consists of entire or partly digested forms of animal groups like Foraminifera, Copepods, Nematoda, Amphipoda, Gastropoda and Lamellibranchs. The

vegetable matter is largely constituted by fragments of the alga *Cladophora* and number of diatoms like *Fragilaria, Coscinodiscus, Pleurosigma, Navicula, Cyclotella* etc.

As the species is found in two different environments, the juvenile phase in the estuaries and adult phase in the sea, growth has to be considered in respect of these two environments. It is clear from the length frequency studies of the backwater as well as the marine catches that the juveniles in the former environment exhibit a quicker growth rate, which may probably be attributed to feeding and environmental factors. By laboratory rearing experiments in younger specimens and length frequency studies of the catches in the older specimens Menon in his studies (1951, 1954 & 1955) arrived at certain conclusion on the growth rate of this species and the size attained in successive years of growth. His results are tabulated below:

TABLE I

Growth rates of *M. dobsoni* in rearing experiments

Initial size (mm)	Period (days)	Final size (mm)	Increase in size (mm)
3.5	81	41.0	37.5
3.5	81	47.0	43.5
3.5	152	43.0	39.5
3.5	76	38.0	34.5
18.0	218	65.0	47.0

TABLE II

Length of year classes of *M. dobsoni*

Sex	1st year	2nd year	3rd year
Male	About 70 mm	About 90-95 mm	About 110 mm
Female	About 75-80 mm	About 100-105 mm	About 120 mm

However by extensive studies of length frequencies of catches from different areas as well as statistical analysis of samples by making use of Von Bertalanffy's equation a slightly different picture showing a faster

growth rate has emerged (George *et. al*. in press, George *et. al*. (1968), Banerji & George (1967). The results of these studies may be summarised as to show a growth rate of 0.35 to 0.372 mm per day in the juvenile stages in the backwater and paddy fields. A size of about 90-95 mm is reached in the first year of life. After this the growth rate is much slow and the size reached at the end of the 2nd year is 115 mm. Thereafter there is very little growth taking plalce in the next year since almost the maximum size is reached by that time. The fishery of the region is thus constituted by the 0-year and 1st year classes.

Differential rate of growth in sexes, females showing a faster rate of growth has been noticed by most authors. The higher growth rate in the female becomes apparent quite early in life, even before reaching a length of about 50 mm.

Behaviour and movements:- As in most other penaeids the life cycle of the species is completed in two types of environments, (1) the brackishwater of estuaries and lakes connected with the sea and (2) the sea. The entire course of larval development is passed in the sea. Migration into the backwaters commences at the late mysis or early postlarval stages. Very rarely a few late larval stages have also been encountered in the backwater plankton of Cochin. Large proportion of the young ones pass into the backwater areas before they reach a length of about 5 mm. During the breeding period successive batches of these young enter the backwaters. The maximum size of the species attained in the backwaters does not exceed 80 mm in length. Kemp (1915) recorded that specimens from the Chilka lake examined by him did not exceed 75 mm in length. The migration back to the sea seems to take place after this size is attained. The largest specimens, measuring about 125 mm, are found only in the sea. Breeding takes place only in the sea and the cycle is repeated after breeding. However it should be mentioned here that the inward migration of postlarvae does not necessarily imply that it is obligatory for completing the life cycle of these prawns. There is good evidence to show that even if they remain in the sea they may be able to grow and become mature. The small size of these prawns found in the catches of the shore seines operated along the coast line in certain season goes to show that these prawns in small sizes are present in the sea also.

A size oriented sexwise movement is noticed in the local populations in the inshore waters of Cochin. Menon (1957) observed that a good percentage of females of the larger size groups move out of the 10 fathom zone probably into deeper water and reappear in the zone after about an years sojourn outside. But Goerge et al.(1968) proved that this particular species may be moving from the regular trawl fishing zone of 5 to 15 fathom to very near the shore; here they may concerntrate in the mud bank areas during the upwelling taking place during the monsoon period.

On the east coast of India Subrahmanyam (1965) studied the migratory pattern of the species in and out of the Godavari estuarine system. He found emigration and immigration of the species more on new moon days than on full moon days. The immigrating prawns were usually more in numbers in the catches at dawn than those at dusk. The period of intense emigration was observed to be February and May. The size of the migrating prawn ranged between 11-15 mm and 86-90 mm size groups with the mode at 46-55 mm.

Large concentration of prawns are known to occur in the mud bank areas along the south west coast of India. These are aggregation of several separate schools of a few species of which *M. dobsoni* is the major constituent. During the monsoon months when the mud banks occur at various places along the coast shoals of these prawns approach the shore in these areas so close as to make it possible for fisher-men to use cast nets for catching them.

Reproduction:- The species is heterosexual as is the case with all the penaeid prawns. Externally visible genitalia are present by which the sexes could be distinguished. These are the thelycum in the female and the petasma in the male. The presence of appedix masculina on the endopod of the 2nd pair of pleopods is a secondary sexual character possessed by the male. The long barb-like spines at the base of the last 3 pairs of pereopods are characteristics of the male. In this species in the adult female the last pair of pereopods remain stumpy. Since this is a feature noticed in adult female only this is probably the result of injury caused by the strong basial spine on the 3rd pereopods of the male during copulation.

In general the reproductive organs are paired and symmetrical. The ovary of the female extends almost the entire mid-dorsal region of the animal and the oviducts terminate at the genital pores at the coxa of the 3rd pair of pereopods. The testes of the male lies in the cephalothorax dirsolaterally to the hepato-pancreas and the vasa deferentia open at the coxa of the last pair of pereopods.

Maturity of the gonads especially in females is attained only in the sea. In the case of males occasional specimens with mature gonads are met with in the brackish water environment. The minimum size at the maturity of the female is 64 mm in total length while in males it is slightly less. According to the nature of the ovary conditions different maturity stages have been observed viz., 'immature', 'early maturing', 'late maturing', 'mature' and 'spent recovering'. In mature specimens dark green ovaries are fully recognisable through the transparent dorsal chitinous shell.

Mating as in other prawns is promiscous. Although no observations are available on the mating habits of the species there are evidences of mating taking place in the inshore waters of the south west coast of India. At copulation the males leave a white paid on the thelycum of the female as a stopper, with the spermathecae underneath. Impregnated females are found in large numbers in the catches during the breeding season.

Estiamtes of fecundity show a range of 34,500 to 1,59,000 eggs. According to Rao (1968) the number of eggs produced vary with size of the prawn in linear lagarithmic form and the formula is Log F = - 07175+ 2.8473 log 1. Fertilization is external, taking place at the time of spawning.

Studies at Cochin and other places along the south west coast of India indicate that the species spawn inside the 15 fathom area in the inshore waters. Though penaeid eggs are believed to be dermsal, large numbers of the eggs are found in bottom as well as surface plankton collections. This indicates that though spawning takes place near the bottom, due to the buoyancy of the eggs they are easily stirred up by disturbances

caused by currents or waves. The species show almost year round breeding with peaks in April, June through August and November-December and it is believed to spawn 5 times during its life time, first spawning taking place after 65 mm length is reached.

Population and fishery

Sex ratio:- The sex ratio of the species in the catches from the backwaters of Cochin as well as the inshore areas along the coast for several years have been described in detail by Menon (1955 & 1957) and are given in table III.

Table III
Sex ratio and percentage of *M. dobsoni* of different age groups in backwater and inshore fishery of Cochin.

Year	All sizes		Over 80 mm			Over 100 mm	
	Female	Female	% in total			% in total	
			Male	Female		Male	Female
1952	52.9	57.4	20.8	25.1	70.7	8.7	18.7
1953	51.3	47.9	38.0	33.1	57.0	17.2	21.5
1954	45.7	43.9	56.8	53.0	73.0	12.4	40.0
1955	45.4	34.5	46.6	30.0	53.4	12.8	17.7
Average	48.6	44.0	41.5	34.5	64.3	12.6	24.0

The sex ratios of the different age groups are shown in Table IV.

TABLE IV
Sex ratio of different age groups of *M. dobsoni*.

Age group	Sex ratio	% in total	
	Female	Male	Female
Backwater catches - 0-year	50.0	..	..
All sizes from sea (0-3 years)	48.6	..	..
Upto 80 mm (1st year classes only)	51.4	58.5	65.5
80-100 mm (2nd year class)	25.6	28.9	10.5
Over 100 mm (3rd year class)	64.3	12.6	24.0

From this he concluded that a good percentage of females of the 2nd year class moves out of the fishing ground, probably into deeper waters and

reappear in the zone after about an year. George & Rao (1967) statistically analysed the data on the sex ratio of the species and other prawns in the catches of the trawl fishery of Cochin for 1962 and 1963 (Table V). They found that in this species the distribution of the sexes varies significantly from month to month. It is suggested by them that the differential sex ratios may be the result of breeding migrations of females.

TABLE V

Sex ratio of *M. dobsoni* in the trawl fishery of Cochin during 1962 and 1963.

Months	Sample size	% males	Sample size	% males
January	993	43.0	1047	49.0
February	1057	44.0	1222	35.0
March	1743	32.0	997	39.0
April	919	45.0	1009	38.0
May	1127	48.0	1069	43.0
June	846	65.0	50	78.0
November	271	55.0	167	59.0
December	390	63.0	196	48.0

Age composition:- Taking the population as a whole the backwater and estuarine fishery is constituted by the 0-year class and the marine fishery by late 0-year class as well as 1-year class.

In the catches of the species from the trawl fishery of Cochin the first year class groups dominate in the beginning of the season from September-October to December-January. Thereafter the first year classes decrease and the late 0-year classes take the place. In the backwater fishery always only the 0-year classes are represented in the catches, up to 8 to 10 months old. In the backwater and paddy field catches 3-4 months old prawns onwards are represented.

Age at first maturity will be about 6-7 months. Maximum age compute statistically is 3 years. Banerji & George (1967) have shown the species reaches a size of about 95 mm at the end of one year and about 115 mm at the end of the second year of its life. Late 0-year and 1-year groups are the maximum represented in the offshore catches.

Size composition:- In the whole population of the backwater and estuaries sizes ranging from 30 mm to 70 mm are found in the catches. In the marine fishery sizes range from about 60 mm to 125 mm. According to Menon & Raman (1961) in the stake net catches of the backwaters of Cochin the modal frequency of the species varied from 41-45 mm and 56-60 mm and the maximum size attained belonged to the 86-90 mm group, the proportion of which never exceeded 2 or 3 percent in any month. In the Godavri estuary the sizes ranged between 11-15 mm to 86-90 mm with the mode at 46-55 mm. In the trawl fishery of the area the modal size ranged between 91-95 mm to 106-110 mm in the earlier months of the season while these sizes declined between 81-85 mm to 91-95 mm in the latter half of the season.

The size at first capture in the backwater fishery varied from 25 to 35 mm length. Size at first maturity is 64 mm according to Rao (*op. cit*). Maximum size attained is 125-130 mm group. Based on 15 observations Hall (1962) gives the length weight relationship formula as :

$W = 0.7691\ C^{2.736}$ where W= weight and C= carapace length.

Abundance and density:- The abundance of the species in the trawl groups of Cochin has been studied by George *et al.* (1968). The total size wise catch in numbers and catch per trawling hour of the species given by them for 3 seasons are reproduced in Table VI.

TABLE VI

Total catch C (in 1000 numbers) and C/E (catch per trawling hour) of *M. dobsoni*.

Size in mm	1961-62		1962-63		1963-64	
	C	C/E	C	C/E	C	C/E
41-45	..	..	11	3	..	..
46-50	..	..	23	7	3	2
51-55	..	..	35	11	13	8
56-60	9	2	48	14	25	14
61-65	63	13	105	31	57	33
66-70	117	23	385	116	132	77
71-75	730	148	847	254	239	139
76-80	1769	358	1124	338	284	165
81-85	3299	667	1386	416	263	152
86-90	5359	1084	1300	391	260	151
91-95	5429	1098	1428	429	251	146
96-100	6178	1250	1402	421	308	179

101-105	5188	1049	963	289	278	162
106-110	2051	415	377	133	108	63
111-115	2673	541	349	105	85	49
116-120	1352	274	183	55	46	27
121-125	238	48	14	4	..	..
126-130	11	2	..	..	..	..

They have calculated abundance of the species with sizes obtained in different months of the season and traced their movement in and out of different depth zones. Changes in abundance at the different depth zones are shown by them.

Natality and recruitment :- George (1967) has tried to correlate the natality and recruitment of the postlarvae into the backwaters of Cochin and the subsequent population contributing to both the backwaters and marine prawn fishery of the species and expressed the opinion that this factor could possibly be used for forecasting of potential yields.

Recruitment of the species into the fishery of 3 centres along Cochin and Alleppey was studied by George (1961) and according to him recruitment of the older classes into the fishery commences by May onwards and along with that the catch per man-hour increases. Thereby showing a distinct relationship between recruit sizes and catch per man-hour so that with the least effort maximum catches are obtained.

The recruitment of postlarval stages into the backwater plankton of Cochin was made use of to determine the breeding season of the species by George (*op. cit*.). The seasonal pattern of recruitment was also studied by him. The seasonal pattern and variations in annual recruitment of the species in the fishery of different depth zones off Cochin was investigated by George *et al*. (op. cit.).

Mortality:- The total instantaneous mortality rate of the species in the trawl fishery ground off Cochin has been worked out by Banerji & George (1967). The average annual total instaneous mortality rate based on 6 season's data was estimated by them as 3.56 and 4.04 respectively by 2 different methods. Based on the data on abundance and size in the fishery off Cochin from the season 1961-62 to 1963-64, George *et al*. (1967)

estimated a monthly instantaneous mortality rate of 0.17 in one particular depth zone - zone II. From this the annual mortality rate works out to 2.04 in that zone. Considering the entire fishing area, pooling together all the zones (data given in table VI) the total annual instantaneous mortality rate (F+M) is estimated by them as 2.41 which is not much different from the estimate for zone II.

Population in the community:- In Cochin waters as well as all along the west coast of India where there is fishery this species exist along with other penaeid species. However, this is the major species contributing to the fishery. In the matter of total prawn landings there is very great difference between different centres as given by George (1961). There are wide fluctuations in the populations at Cochin as noticed by George et al and others. The nature of these may be summed up as given by George *et al*. (1967), as follows. " the distribution of abundance over the three years of observation show a decreasing trend, particularly in zone II where the maximum exploitation is taking place at present. Decreases in abundance in the same fishery from 1958-59 onwards also was observed, but the unusually large catches in 1961-62 tend to show that it is only due to natural fluctuations. The trend of decrease is continued later also as shown by the present study, and may well be attributed to natural fluctuations, especially when the instantaneous mortality of the major constituent of the fishery, *M. dobsoni*, is estimated as being very low (Banerji & George 1967). Nevertheless, this declining trend may cause apprehentions to the industry and has to be very carefully watched. The distribution of fishery effort, which is now concentrated in zone II where this trend is particularly evident, may be advantageously directed to the deeper zones where the possibility of better yield of large sized prawns, exist as pointed out here".

Fishing gear :- Different zies of boat seines are the main gear employed in the fishing of the species along with other prawns in the inshore waters along the west coast of India. These nets are operated by the indigenous craft and are locally called 'thangu vala', 'vatta vala', 'koru vala' etc. Shore seines locally called 'kamba vala', 'nona vala' or 'kara madi' are also operated in this area for prawn fishing from the near shore areas. In the north Kanara coast shore seines called 'yendi bala'

are employed. In Bombay area bag nets or 'dol nets' are the gear operated in the shallow areas.

In the backwater and lake fishery the stake net ('ooni vala'), the Chinese dip nets ('cheena vala'), the cast net ('veechu vala') and the drag net ('vadi vala') are the important gear in use for catching these prawn. An ingenious method of fishing locally known as 'changala paachil' is also in use in Cochin backwaters (Gopinath 1953). A variety of wall nets are also used in many shallow areas along both west and east coasts. On the east coast a bottom drag net ('thuri vala') is used. Devices like long fences with rings of traps at the inner ends are employed for catching prawns in the inside waters along the east coast. In the paddy field prawn fishery of the south west coast conical nets fixed on rectangular frames are operated in sluice gates, as described by Panikkar (1937) and others. Hornell (1925 & 1938) describes several indigenous gears in which prawns are caught and their mode of operation in the Madras area.

After the introduction of mechanisation of fishing crafts in India conventional trawls of various sizes are in use in the trawl fishery for prawns from the offshore waters. In Cochin waters most common shrimp trawl is the 2 to 4 seam trawl varying from 13 to 18 metres in head rope length and with mesh sizes of 76 mm, 50 mm, 38 mm and 25 mm for the wing, body, throat and cod end respectively, used mostly by the smaller mechanised vessels. Bigger trawl nets are operated by a few bigger boats. The trends in development in the prawn fishing gears in India has been reviewed by Kurian (1965). Echo sounding equipments are used in all the bigger size boats for locating prawns.

Fishing boats:- On the west coast of India the indigenous gears are operated by the traditional dug out canoes and plank built boats with out-rigger. On the south west coast south of Trivandrum and along the east coast the catamaran is the craft used. In Godavari estuary two types of country craft are in use, namely, 'shoe-dana' and 'nava'.

In the mechanised fishery generally the medium sized pablo boats of 7 to 11 metre size powered by 10 to 30 b.h.p. engines are in use. A few slightly bigger type shrimp trawlers are present in some centres of operation. The trend in development is to construct bigger vessels of suit deeper water prawn fishing ventures.

Fishing areas :- Juveniles are fished in the backwaters, lakes and estuaries including paddy fields of Cochin backwaters in shallow areas ranging from 1 to 15 metres. Young adults and adults are caught from the sea in depth up to 25 to 30 metres. In the trawl fishery of Cochin George *et al*. (*op. cit*.) reports a concentration of the species in the 12-15 metre depth zone. Variations in abundance of the species in different depth zone has been studied. Muddy substratum is found most suitable for the species.

Fishing season :- In the marine inshore areas of south west India the fishery for the species is largely seasonal extending to several months. In the paddy fields of this region and in the Collair lake it is seasonal while in the backwaters of the same area it continues almost throughout the year. In the paddy fields of Kerala prawns are fished from the middle of November to the middle of April. In Collair lake the fishery is from May to December. In Godavari estuarine system migrant prawns of this species are abundant from November to May with peak periods in January and February. The marine fishery of the south west coast coincides with the monsoon period, usually from June to September. Tables VII and VIII show variations from month to month in the percentage of *M. dobsoni* in the prawn catches of Kerala. Table VII refers to the fishery for juvenile prawns in paddy fields and backwaters and shows *M. dobsoni* to be the dominant species from August to April. Table VIII refers to the inshore marine fishery and illustrates that the percentage of *M. dobsoni* in any month may vary considerably from year to year. The offshore fishery in this area extends from about November to June with a peak in the 2nd half of this period.

TABLE VII

The percentage values (Numerical of *M. dobsoni* in the monthly prawn catches from paddy fields and backwaters. Dashes indicate no record available

Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.
1951-52	-	74.6	81.6	80.8	79.2	84.5	-	-	47.0	74.8	75.4	91.3
1952-53	87.9	82.3	89.8	89.5	67.1	45.7	42.1	29.6	46.6	66.5	71.3	80.8

TABLE VIII

The monthly average percentage values of *M. dobsoni* in the marine prawn caches at Narakkal

Year	April	May	June	July	Aug.	Sept.	Oct.
1952	74.0	41.6	38.5	79.6	55.8	8.2	-
1953	-	26.3	55.3	24.0	33.5	51.0	16.2

The marine fishey in south west India shows local variations in the times of beginning and ending and also peak occurrence, varying up to 2 months this side or that. The formation of mud banks, locally called "chaakara" is noticed to influence the inshore fishery of Kerala coast. Here intensive fishing for prawns, particularly this species, is found to commense only with the formation of these mud banks. Other factors suggested to have some influence on fishing in the backwaters of Kerala and other areas are rainfall and lunar periodicity. The influence of lunar periodicity on immigration and emigration into the Godavari estuary was studied by Subrahmanyam (1965) and he found more on the new moon days than the full moon.

Fishing operation and results :- George (1961) studying the prawn catches, mostly contributed by this species, from three centres along the Kerala coast during the years 1956 to 1960, used total effort and intensity of fishing to establish a relationship between catch per man hour and recruit sizes.

In the trawl fishery of Cochin, George *et al* (in press) observed the effort and intensity of fishing through the years 1958 to 1963 and reached the conclusion that there is no overfishing in the area. George et al (1967) utilized the catch and effort data till 1964 for determining the abundance and its variation in the Cochin grounds.

The total catches of this and other species at the inshore fishing centres at Alleppey, Chellanam and Narakkal on the Kerala coast have been given by George (1961). Wide fluctuations in these catches were noticed by him in the years 1956 to 1960. Menon and Raman (1961) gave total catches of prawns at two centres in the Cochin backwaters. The trawl catches

of Cochin for the years 1957 through 1963, also show year to year fluctuations. The total catch figures of boats operated by the Indo-Norwegian Project and the Deep Sea Fishing Station of the Government of India in respect of this particular species for 1957 to1963 (Table IX) are given by Banerji (1965) and Banerji and George (1967).

TABLE IX

Trawl catches of *M. dobsoni* off Cochin.

Year	Catch (kg) C	Effort (Tr. hour) E	U = C/E
1957-58	99,301	2,734	36.32
1958-59	146,768	3,526	41.63
1959-60	67,320	3,958	17.01
1960-61	40,073	2,611	15.35
1961-62	174,121	4,547	38.29
1962-63	50,349	3,793	13.27

Subrahmanyam (1965) gives the total catches of the species along with other species for new moon and full moon periods separately in the Godavari estuarine system on the east coast of India. He also gives high tide and low tide catches of these prawns. Annual reports of the Indo-Norwegian Project show the total catches of this species caught by their mechanised boats at different centres on both coasts of India.

Protection and management :- On the south west coast of India the only regulation now in existence is in respect of the paddy field fishery in which this is the most important species. The fishery is allowed to operate from the middle of November to the middle of April only. According to Panikkar and Menon (1956) “this is done not so much in the interest of the fishery as in that of rice cultivation”. They are of the opinion that “the methods of fishing now in vogue do not involve the destruction on any appreciable scale of prawn fry and leave sufficient numbers of breeding females to replenish the stock. The fear of depletion has not

therefore arisen anywhere and thus no serious problem in management, requiring regulation of the fishery, has confronted the Government of the various States". There is a licensing system or the cast net, stake net and chinese net fishery and paddy field fishery of the backwaters of the south west coast of India.

Prawn culture :- There is no farming or culture of this species anywhere. Trapping of adolescent stages, mostly this species, is prevalent in the extensive rice fields of coastal areas of Kerala in South India. A few decades ago actual culturing by rearing young prawns for 2 or 3 months used to be in vogue there, but the current pracice seem to be only to trap the shrimps in the paddy fields with the incoming tide, after the annual crop of rice, and to fish them during favourable low tides at night. Soon after the rice cultivation, in about October, blocks of individually owned fields are leased to prawn fishermen for about 5 months. The dykes are strengthened and sluice gates installed. The flow of water in and out of these fields is regulated through there sluices. The water is let in at high tide and out at low tide. During favourable low tides at night a conical bag-net is fixed at the opening of the sluice. While letting in water at high tide and while fishing, a lamp is hung at the mouth of the gate. In these fishing processes very little attention to the stock is called for, although during the few hours or days that the trapped shrimp remain in the field they utilise the food organisms within the field and grow to a certain extent.

2. *METAPENAEUS MONOCEROS* (FABRICIUS 1798)

Common name :- Vernacular names :

India - Kerala coast	-	Choodan chemmeen
Bengal coast	-	Koraney chingri, Honya chingri
Bombay coast	-	Jinga
Gulf of Kutch	-	Sonayya jacha
East Pakistan	-	Kucho chingri
West Pakistan	-	Kiddi

Diagnostic features :- Body covered with a harsh and very short tomentum. Rostrum nearly straight, uptilted, reaching neraly to, or a little beyond, the tip of the antennular peduncle; armed with dorsally 9-12 teeth, which do not form a crest. Post-rostral carina continued to, or almost to, the posterior border of the carapace. Anterolateral angles of carapace broadly rounded off. A very small supra-orbital spine present. Antennal spine strong, produced as a salient ridge to the base of the small hepatic spine, the ridge bounding a well marked post-antennular groove which meets the cervical groove. Gastric region defined anteriorly, on either side of the rostrum, by a short oblique post-orbital sulcus. Branchial region defined anteriorly by a deep and narrow crescentic groove (anterior part of cervical groove) which embraces the base of the post-antennular ridge and meets the post-antennular groove and superiorly by a sinuous ridge (most distinct in its posterior half) which runs from the hepatic spine almost to the posterior border of the carapace (Fig. 11a).

The abdominal terga are carinated mid-dorsally, the 1st, 2nd and 3rd bluntly, incompletely and somewhat inconspicuously, the 4th to 6th very sharply and almost completely. The 5th abdominal somite is about 2/3 length of the 6th and the 6th a little shorter than the telson which is shorter than the inner caudal swimmeret and without marginal spines.

Eyes very large; slightly surpassed by the antennular scale. The outer antennular flagellum which is slightly longer than the inner is not much more than half the length of its peduncle.

The 3rd maxillipeds barely reach the middle of the antennal scale; their dactylus in the male is not modified, but consists of a slender, setose, tapering joint about 4/5 length of the propodite with which it is articulated end-on.

There is a strong antrose spine on the basis of all 3 pairs of chelipeds. In the adult male the last pair of thoracic legs has the proximal end of the merus notched on its outer side, the notch being deepened anteriorly by a large retrorse and introrse, hook-like spine and posteriorly by a subterminal lobule on the posterior border of the ischium. Beyond the spine the edge of the merus is finely denticulate. In both sexes the three terminal joints of these fifth legs are slender, and the dactlylus rarely reaches much beyond the middle third of the antennal scale. No exopodite is present on the fifth pair of legs.

The petasma is quite symmetrical (fig.11b). In the adult it consists of two rigid segments tightly folded in all their lengths interlocked all along their anterior margin, and in close apposition along a great part of their posterior margin, so as to form a compressed tube. The median lobe is distally produced into a large gargoyle. The lateral lobes end in 3 projections, masked by the hood-like projections of the median lobes on the ventral side. The dorsal lobule of the median lobe is produced posteriorly into a prominent projection with rounded apex. On both sides of these projections the posterior margin is raised into well calcified, triangular projections. The lateral sides are the posterior edge of which gently curves up sidewise.

The adult thelycum (fig.11c) has a concave central region bounded anteriorly by the median plate, laterally and posteriorly by the lalteral plates and dorsally by the posterior hollowed out region of the median plate, the two oval plates on the sides of these and the anterior hollowed out regions are of the lateral plates. The lateral ridges of the lateral plates are considerably raised to form an ear shaped structure. The anterior edge of this ridge possesses sparesely set small setae. The anterior half of the median plate is broader and has a distinct groove medially. The posterior half is narrower and descends down forming part of the roof of the concave portion, the posterior tip ending in two slightly elevated

knobs. The portion of the concave region between this posterior part of the median plate and the lateral plates is occupied by the two oval plates. The anterior margin of the median plate is beset with setae. The lateral sides of the same also possess setae especially the middle region. The coxae of the 4th pereopods have a sharp vartical ridge which is in close approximation with the sides of the median plate. The posterior ridge of the last thoracic sternite is beset with long setae.

The species attains a maximum length of about 180 mm.

Colouration :- They are semitransparent, closely covered with small reddish chromatophores. The dorsal carina of the carapace, rostrum, the bases of the eyestalks, the dorsal abdominal carinae and the carinae of the telson and uropods are defined by dull red pigmentation. The antennae are bright red. The first two legs are more or less colourless and the last three with numerous red chromatophores. The setae that fringe the uropods are golden red and the exopod of the uropod is bright red along its external margin.

Distribution

General distribution:- The species is distributed in South Africa, Mediterranean and Indian seas to Malaysia with the eastern limit as Malacca Strait. Under the FAO distribution code (Holthuis and Rosa 1965) the distribution of the species in land areas is in 122, 136, 154, 413, 421, 423, 425 and 556. In water areas it has a distribution in the regions ISW and ASE. Although it is a marine species it is found in marine, brackish water and fresh water environments.

In Indian waters it occurs in the juvenile stages in most of the estuaries and backwaters with muddy bottom along the coastline and adults in the sea up to 50-60 m depths, both muddy as well as sand and silt bottoms.

Differential distribution of stages :- There is no information on eggs and early larvae. Late mysis and postlarval stages of the species migrate into backwaters and estuaries all along the coastline of India and the juveniles contribute to a fishery in these waters. Based on the occurrence of large numbers of the postlarvae in the Adayar estuary

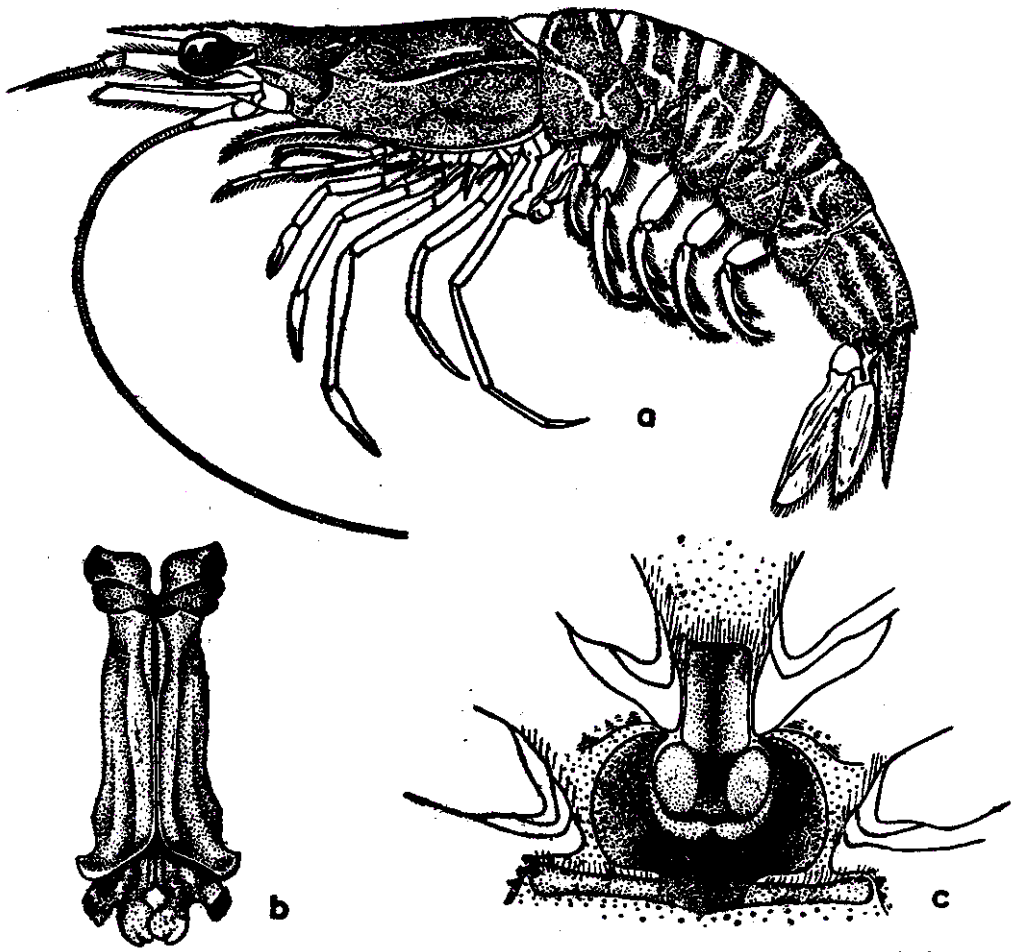


Fig. 11. a. *Metapenaeus monoceros* (Fabricius); b. Petasma; c. Thelycum.

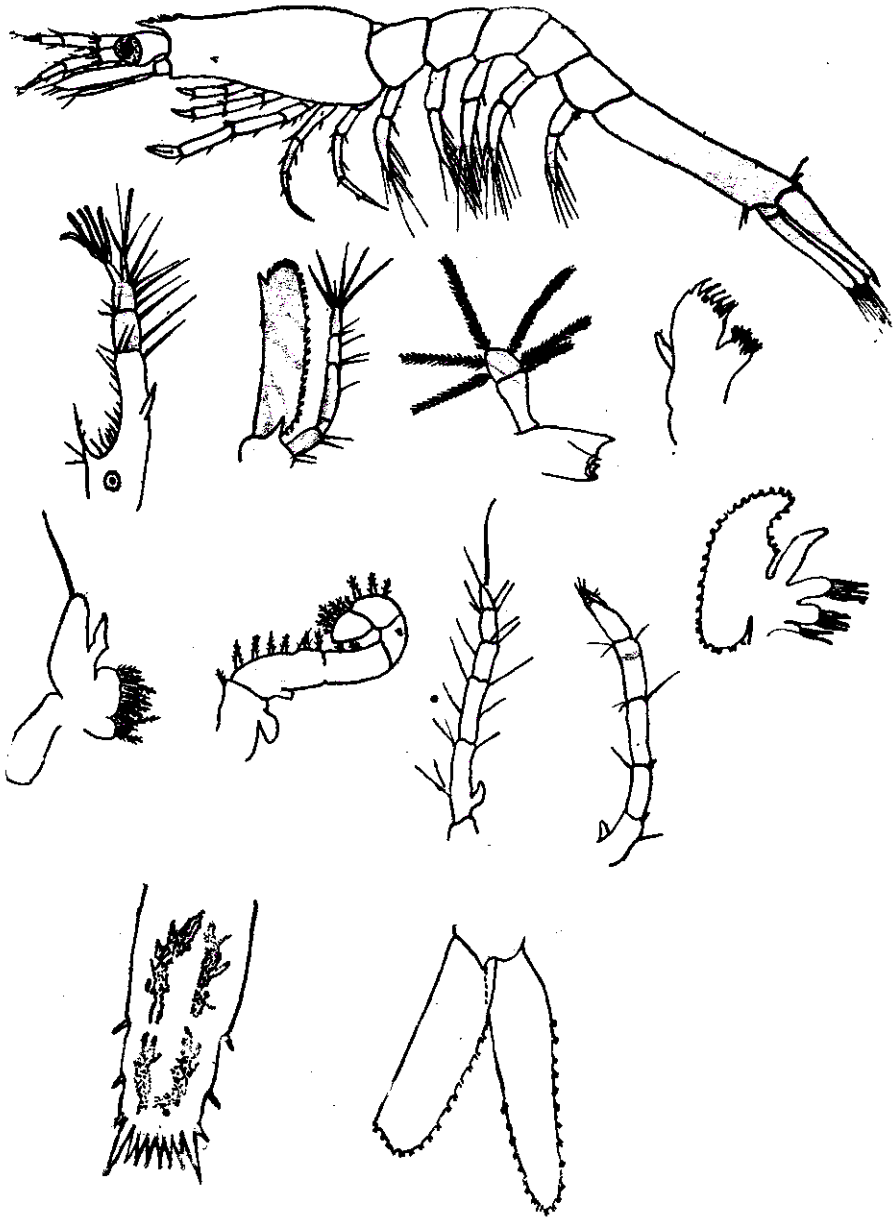


Fig. 12. Postlarva of *M. monoceros* and appendagee.

Panikkar and Aiyar (1939) even suspected the possibility of the species breeding in the inside waters. Juveniles and medium sized specimens are distributed widely in the Gangetic delta area. In Bombay waters juveniles are present in the inshore areas. The adults are found to occur in slightly deeper waters of the sea. A breeding population has been located in 50-60 m depth off Cochin.

Life history

Eggs and larvae:- So far there is no work on the early larval development of the species. The first postlarva has been, however, described by Mohamed *et al*. (1967) and the figures given by them are reproduced (fig. 12). It has a carapace length varying from 1.104 mm to 1.112 mm and total length from 3.75 to 3.95 mm. Rostrum is small with a pair of dorsal teeth, each having a smaller spine behind, and not quite reaching middle of the eye. Antennal and hepatic spines are present. Inner branch of distal segment of antennule 2-jointed with 4 setae and outer branch faintly segmented. Flagellum of antenna 4-5 jointed and antennal scale with 26 setae. Mandibular palp jointed, distal segment with 5-6 setae. Maxillular endopod unjointed. Maxilla with 3 endites, palp unjointed and scaphognathite with 32 setae. 1st pair of pereopod with basial and ischial spines, 2nd and 3rd with basial spine only. Median dorsal spine present on the 6th abdominal segment. Distal lateral aspect of the same segment with 2 or 3 pairs of setae. Spine formula of telson 7+7. Due to presence of large number of brownish red chromatophores along the entire ventral aspect of the postlarva it appears brownish. This is very characteristic of the species.

The postlarval recruitment into the backwaters of Cochin has been studied in detail. Rearing of the animal from early postlarvae from about 3.0 mm in total length was also carried out in the laboratory to study early growth rate.

Nutrition and growth:- The species has an omnivorous feeding habit. The major items in the stomach contents are the remains of Crustaceans like Amphipods, Isopods and Copepods, Polychaet remains, Vegetable matter like angiosperm tissues and diatoms, Foraminifera, Mollusc shell pieces

and sand particles. A slight predominance of Crustacean remains is noticed in general in a study of the stomach contents of 1173 specimens.

Results of laboratory rearing experiments on growth rates given by George (1959) are reproduced in Table X.

TABLE X

Growth rates of *M. monoceros* in laboratory rearing experiments

Period of experiment in months	Initial size mm	Final size mm	Increase in size mm	Rate of growth per month mm
4	3.0	33.5	30.5	7.63
4	3.0	33.0	30.0	7.50
4	3.0	34.0	31.0	7.75
4	3.0	28.0	25.0	6.25
8	3.0	60.0	57.0	7.13
4	3.5	36.0	32.5	8.13
6	3.0	46.0	43.0	7.17
4	3.5	44.5	41.0	10.25
4	3.5	43.5	40.0	10.00

The rate of growth varies between 6.25 mm and 10.25 mm from which the average growth rate works out to 7.98 mm per month. Rearing experiments conducted by him in paddy fields, however, showed a lesser growth rate of 10-15 mm during the course of 3 months in the case of juveniles. This lesser growth rate may be due to the decrease in growth rate taking place in larger specimens. But a much faster growth rate in the paddy fields was obtained by length frequency analysis of catches from paddy field fishery later. In the Gulf of Kutch area a very fast growth rate, attaining 4 inches in 5 months has been recorded for the species.

Differential growth rate in sexes as in other species, females showing a faster growth than males, is noticed in this also. Moult frequency in laboratory reared animals as well as that of the catches from Cochin backwaters in the juvenile stages has been investigated and a total number of 32 moults during a period of growth from 3 mm to about 100 mm size recorded.

Behaviour and movements:- The migration at postlarval stages to backwaters and estuaries takes place all along the coastline of India.

The preesnce of postlarvae in large numbers in the estuaries at Madras and other places have led to the doubt that the species is breeding in these inside waters (Panikkar & Iyer 1939, and Gnanamuthu 1966). But George (1959) shows that this is not the case and evidence from the Cochin brackishwaters definitely indicate that it does not breed in the brackish waters. Here migration into the backwaters from the outside sea takes place at early postlarval stages and movement back to the sea commences after a length of about 100 mm is reached in these less saline environments in less than 1 year's time.

In the offshore trawling grounds movements of the bigger sizes into the shallower grounds from deeper waters have been noticed in the early part of the season in November. Offshore migration commences later and by about April all prawns larger than 80 mm size are found to move out of the shallow areas upto a depth of about 25 fathoms.

In the Gulf of Kutch area these prawns are found to move to deeper waters and open seas from August to November and it is believed that this movements is not for the sake of feeding but probably for spawning. Movement to deeper waters for spawning is evident in Bombay waters also.

On the east coast of India in the Godavari estuary the migratory movement is almost nocturnal and immigration is more during dawn. Generally the immigrants and emigrants here are seen relatively richer on the new moon days than on full moon days. The outward migration is quite intense in the months December, May and June.

Reproduction:- As in other species this is also heterosexual. Sexes are distinguished by external genitalia, petasma and thelycum (fig.11b&c), the development of which has been worked out by George and Rao (1967). In the adult male in addition to the petasma the proximal end of the merus of 5th pereopod is notched, bounded anteriorly by a large hook-like spine and posteriorly by a lobule of the ischium. Although not a case of hermaphroditism, George (1963) recorded a specimen with both thelycum and petasma, the latter only partly developed.

The different stages in the maturity of females like 'immature', early maturing', 'late maturing', 'mature', and 'spent' have been noticed

rearely in the trawl catches off Cochin. A concentration of the species with late maturing and mature stages of gonads has been reported from 50-60 m. depths of Cochin. In Bombay waters it does not attain maturity in the inshore regions. From the studies in the backwaters of Cochin it has been proved that it does not attain maturity in the inside waters and also before 120 mm length is reached.

Mating as in other prawns is promiscuous. Fertilization is external taking place at the time of spawning. There is no information in the mating habits and fecundity.

The spawning season in Cochin waters is prolonged with two peaks, first in July-August and second in November-December. In the Gulf of Kutch area the spawning season is from February to April.

A possible spawning ground for the species at and around the sand shelves in the 50-60 m. area off Cochin was located by George & George (1964).

Metabolism - Osmotic relations:- Active regulations of chloride and osmotic behaviour of this species of penaeid prawn has been extensively studied by various authors in India. Panikkar (1948) studied this prawn in comparison with other penaeids and found that it can survive the highest salinity ranges, both low as well as high. The distribution of this species in relation to this osmoregulatory behaviour has been discussed by him. Panikkar and Viswanathan (1948) experimented on the changes in the chloride content of the blood of this species by employing the micro modification of the Volhard titration. According to them the hypotonic osmoregulation in this prawn is achieved as a result of the active regulation of the chloride ion.

Oxygen consumption as a function of size and salinity in this species from a marine as well as brackish water population was the topic of study of Rao (1958). He has noticed differences in the rate of oxygen consumption in the different media (oxygen consumption increases with increasing hypertonicity or hypotonicity of the medium) and attributed this to the osmotic adaptation of the prawn. He found that relatively high 'b' values (regression of oxygen consumption with weight) are

obtained in natural media and that the 'b' values tend to decrease on either side of normal salinities. Comparing two natural populations of the same prawn in media of different salinities, he suggested that the pattern of response to osmotic stress in the oxygen consumption of this prawn depends on the salinity of the medium to which the animal is naturally adapted.

Reddy (1963) has shown that immediately on transfer to anisosmotic media of 5% or 35% salinity, the chloride concentration of the blood as well as the rates of heart beat, of respiration and of urine production change and these rates attain a steady level after about 8 day's stay in the anisosmotic medium. Thus these prawns become acclimatised to any medium in about 8-10 days. He also found that in prawns acclimatised to sea water of 5%, 20% and 35% salinity the blood amounted to 31.65%, 28.1% and 26.2% respectively of their body weights. Gnanamuthu (1966) tried to correlate these changes with changes in body volume of the same prawn. According to him the gut of the animal is capable of altering the volume of the whole body by taking in and giving out water through the mouth and anus. He has proved that the decrease of the body volume in prawn acclimatised to dilute medium and the increase of body volume in concentrated medium, as well as the fluctuations in volume of prawns acclimatised to anisosmotic media are features associated with the part played by fluid pressure in active regulation of water across the gut wall. He is of opinion that the maintenance of osmotic equilibrium in dilute or concentrated media without any marked increase of energy expenditure is more satisfactorily explained on this basis of movement of water than of ions because the mascular action of the gut is a feature of the prawn even under isosmotic conditions.

Population and fishery

Sex ratio:- From a study of the sex ratio of the juveniles in the backwaters of Cochin during 1952-53 through 1954-55 a slightly higher percentage of females is seen in all the years, the respective percentage of females for the 3 years being 51.76, 51.08 and 51.31. In the catches of the juveniles of the species from the inshore waters of Bombay also a predominance of females over males is recorded except in the month of June.

Age composition:- Only the 0-year classes contribute to the backwater fishery of Cochin. In the trawl catches off Cochin 3 year classes with modal length 100-110 mm, 131-135 mm and 156-160 mm are recorded. The bigger year classes enter the fishery in November-December and the smaller sizes appear later. It is noted that in some years the bigger classes fail to appear in the fishery.

Size composition:- As in other species juveniles contribute to the estuarine and paddy field fishery. In Cochin backwaters specimens measuring more than about 100 mm in length are very scarce. The modal lengths vary from 56-60 mm to 86-90 mm. The sizes of migrating prawns of this species in the Godavari estuary ranged between length groups 11-15 mm and 91-95 mm with the modal lengths of emigrants at 46-55 mm and the immigrants showing comparatively smaller sizes.

In the inshore fishery of Bombay the sizes range in length from 40 mm to 120 mm mostly juveniles. The adults caught in the trawl fishery off Cochin are in the size range from 90 mm to 175 mm with the modal lengths varying from 126-130 mm to 146-150 mm.

The size at first capture in the backwater fishery is 30-35 mm. The maximum size attained is 180 mm which is reached in the deeper waters.

Based on 175 observations the relationship between weight and total length is expressed by the formula

$$W = 0.01989\ L^{2.7603}$$

Abundance and density:- The abundance of the species in the trawl grounds off Cochin for the years 1961-62 to 1963-64 was studied in detail by George *et al*. (1968). The abundance in different depth zones was correlated to sizes in order to study the size oriented movements in and out of the zones. Generally an increase in abundance was noticed in the earlier months of the season with subsequent decline.

Natality and recruitment:- The recruitment of the postlarval stages into the backwaters of Cochin has been studied and the possibility of the use of this factor for predicting the subsequent fishery has been

suggested. The recruitment of these stages was also studied to determine the breeding season of the species in the area.

The recruitment of the different year classes into the trawl fishery of Cochin was studied and it is found that bigger sizes get recruited into the fishery early in the season and smaller sizes in the latter half of the season.

Fishing gear:- In short in Bombay area the 'dol' net or bag net is the common gear used for catching prawns. In North Canara coast 'Yendi bala', a shore seine is used. On the south west coast various types of boat seines (locally called thangu vala, vatta vala, Koru vala), shore seines (Kamba vala, nona vala), drag nets (vadi vala), stake nets (ooni vala) and cast nets (veechuvala) are employed. On the east coast stake nets, drag nets, push nets and screening traps are important in prawn fishery. In the mechanised fishery for prawns various sizes of shrimp trawls are used.

Fishing boats:- The indigenous gears are mainly operated by dug out canoes, plank built boat with outriggers and catamarans. The powered fishing boats are generally the medium sized 7 to 11 m pablo boats having 10-30 b.h.p. engines. A few larger boats with higher capacity are also operated.

Fishing areas:- Juveniles are fished in the backwaters and estuaries along the Indian coast including shallow waters and paddy fields in Kerala. The depths of thsese vary from 1 to 5 or 6 m. Adults are fished in Cochin region up to a depth of 50 to 60 metres. In Bombay waters it is fished from the inshore areas of depth range from 7 to 12 metres.

Fishing season:- On the west coast of India the seasonal pattern varies according to the type of fishery. While the species is most abundant in the backwaters of the south west coast of India in March to June and in November, the season in the trawl fishery of the coast is November-December. In the inshore fishery of the north west coast the season is in the middle of the year. The November-December season is common to the estuarine fishery of the east coast also.

In the backwater fishery of Cochin, although represented throughout the year, the species is most abuncant in the months March to June and November. The percentage contribution of the species given by Menon & Raman (1961) is reproduced in Table XI.

TABLE XI

Percentage values in the monthly catches in the stake net at Cochin in 1957-58.

%	Jan.	Feb.	Mar.	April.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
by no.	10.5	9.6	18.9	22.3	12.3	16.5	14.2	9.0	12.3	11.9	35.8	5.4
by wt.	21.2	21.6	32.0	36.7	33.2	35.8	29.2	27.9	36.3	28.9	63.4	17.7

The peak season for the species in the trawl fishery off Cochin is November-December. Usually it appears in the catches in small numbers by October, reaches the peak in November and disappears by the end of December. Smaller sizes are represented again in the fishery in small numbers in March-April.

In Bombay waters, although present throughout the year, the peak of the fishery is during the rainy season in July and August. The percentage contribution of this species at Sasoon Dock in 1952-53 is 7.0%.

The species is found in Chilka Lake all through the year. In Godavari estuary although present in the catches throughout the year it is more abundant from November to May-June with peaks in November-December and May-June.

On the west coast of India there is difference in the peak seasons between the northern region and the southern region. Apart from the difference in the peak season, variation in the season of the species in the same locality is recorded in the trawl fishery off Cochin. November-December being the months of peak occurrence in this fishery usually, in certain years failure of the species to appear in the catches in these months has been noticed. The exact reason for the same is not yet evident. The formation of mud banks, locally called “chakara” is noticed to

influence the inshore prawn fishery in general of Malabar coast. Factors recorded to have certain influence on fishing in the backwaters of Kerala are rainfall and lunar periodicity. A direct relationship between rainfall and prawn catches have been noticed here. Also highest catches are recorded on new or fullmoon days or a day or two later. In the Godavari estuary more numbers of the species are observed in the catches on new moon days than on half moon days.

Fishing operation and results:- The effort and intensity of fishing of the species along with others in the trawl fishery of Cochin was studied through the years 1958 to 1963 by George et al (in press). They give the total catches of prawns including this species. Menon & Raman (1961) give the total catches of prawns for 1957 and 1958 for two centres in the backwaters of Kerala. Subrahmanyam (1965) gives the catch figures of prawns in the Godavari estuary for new moon and full moon days as well as high and low tides.

3. *METAPENAEUS AFFINIS* (H. MILNE EDWARDS 1837)

Common name:- In Malayalam, on the south west coast of India, the species is locally known as "kazhanthan chemmeen". In Bombay, on the north west coast, it is locally called "jinga" and in Bengal on the east coast, it is known as "chingri".

Diagnostic features:- Body tomentose; rostrum more curved, less uptilted, slightly larger than that of *M. monoceros*; not less than 9 dorsal teeth; postrostral crest does not extend to posterior part of carapace; anterolateral angles of carapace rounded; antennal spine strong, produced as salient ridge to small hepatic spine; ridge bounding well marked post antennular groove which meets cervical groove. Anterior abdominal terga indistinctly carinated; 5^{th} abdominal somite $^{2}/_{3}$ length of 6^{th} which is little shorter than telson. The telson without marginal spines and shorter than endopod of uropod.

Eyes very large, slightly surpassed by antennular scale. Upper antennular flagellum at least 3/4 length of peduncle. 3rd maxilliped barely reaches middle of antennal scale, dactylus of male not modified. Strong spines present on bases of all 3 pairs of chelipeds. Last pair of thoracic legs usually surpassing tip of antennal scale, sometimes by whole length of dactylus; no lobule on posterior edge of ischium in male, notch in the merus bounded by twisted tooth, edge of merus entire beyond tooth. No exopodite on fifth pair of legs (fig. 13a).

Petasma symmetrical. In adult, 2 halves from compressed tube ending in a pair of two-lipped spouts like short horns (fig. 13b).

Thelycum concave and setose. Lateral lobes fairly flat, transversely cut into unequal segments. Median plate projects between 2 lobes of the sterum between 4th pair of legs. The anterior half of this plate has a median groove (fig. 13c).

The species attains a maximum length of about 180 mm.

In life body is translucent bluish green mottled with chromatophores. Uropods tipped with conspicuous green.

Distribution

General distribution:- General distribution of the species is Indian seas through Malaysia and Part of Indonesia to Hong Kong and Japan. Under the FAO distribution code (Holthuis and Rosa, 1965) it occurs in land areas 421, 423, 433, 434 and 437, and water areas ISW and ISEW, in marine and brackish waters.

In Indian waters, the juveniles of the species are found in very small numbers in the backwaters and estuaries and adults occur in the inshore waters to a depth of about 45 metres.

Differential distribution of stages:- There is no information on distribution of eggs and larvae. There are indications that the species is breeding in the inshore waters of the south west coast of India (Subrahmanyam 1967 and Rao, in press). But there does not seem to be such

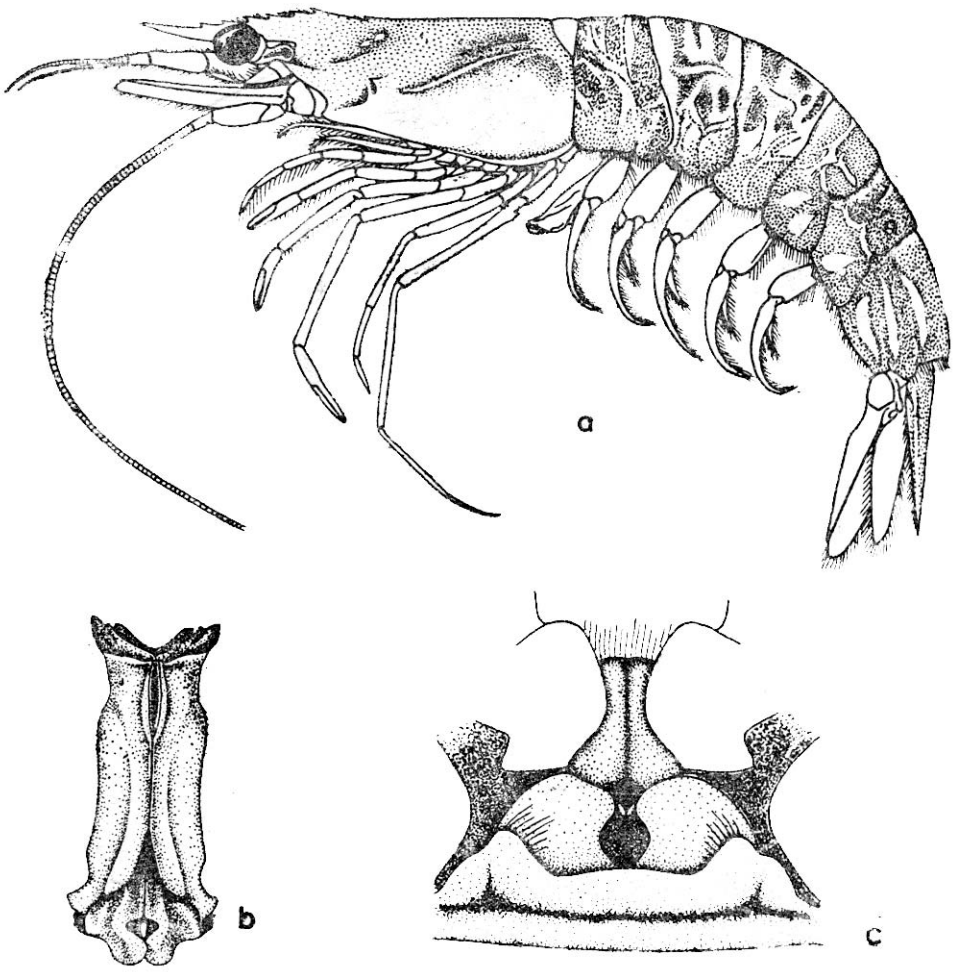


Fig. 13. a. *Metapenaeus affinis* (H. M. Edw.); b. Petasma; c. Thelycum.

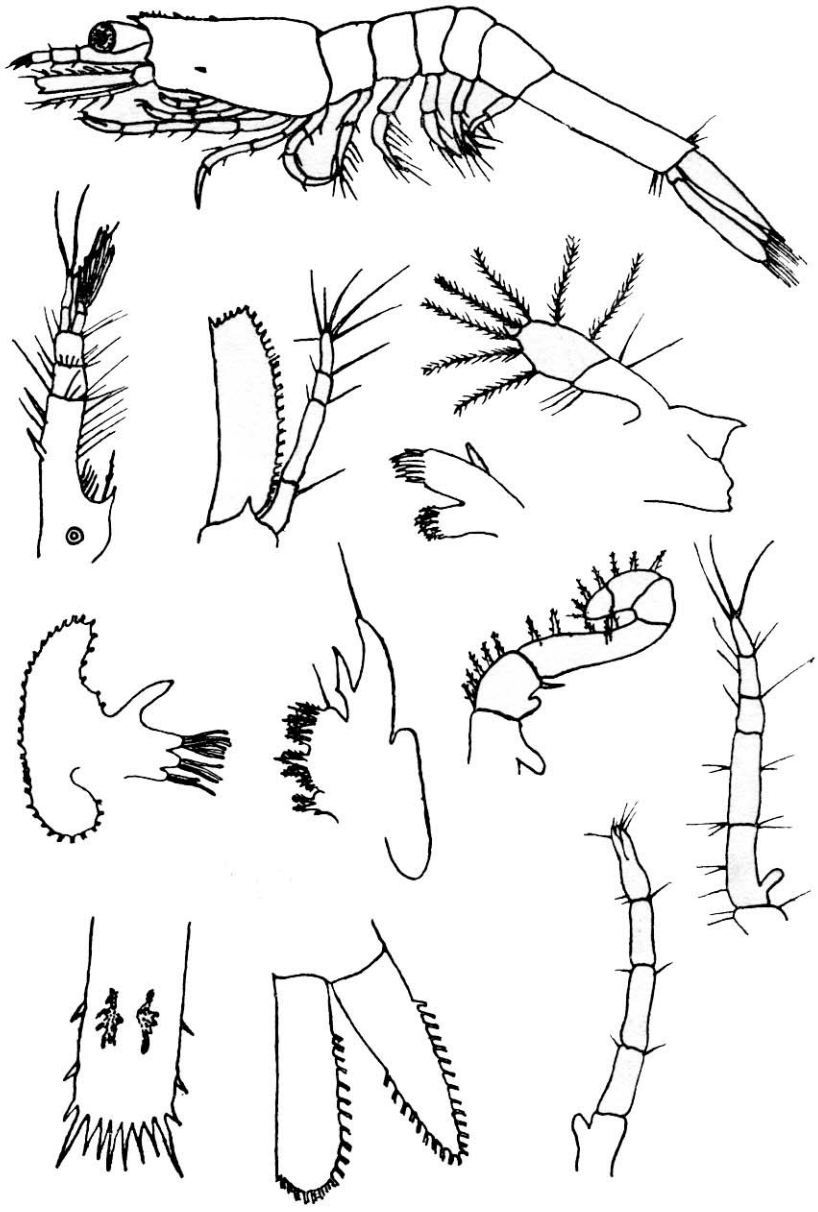


Fig. 14. Post larva of *M. affinis* and appendages.

large-scale migration of the postlarval stages into nearby estuaries as in *M. dobsoni* and the species never accounts for more than a small percent of the catch in the fishery for juvenile prawns in the backwaters of Cochin. In the Chilka lake and other inland waters on the east coast of India also the species is present through all the seasons.

Life history

Eggs and larvae:- The complete larval history of the species is not known from any Indian work. However, Hudinaga (1941) described 6 moultings in the nauplius stage, 3 in the protozoea and 3 in the mysis stage, after which the larva passes into the postlarva. The first postlarva has been described in detail recently by Mohamed *et al*. (1967) and their figures are reproduced in fig.14. It ranges in total length from3.85 to 3.95 mm and carapace length from 1.168 to 1.170 mm. The rostrum is small, just projecting beyond frontal margin of carapce with 2 pairs of dorsal teeth and 1 epigastric. Antennal and hepatic spines present. Inner and outer branches of distal segment of antennule faintly jointed and with 3 setae on inner branch. Flagellum of antenna 4-jointed and with 26 setae on antennal scale. Mandibular palp jointed, distal segment with 7-8 setae. Endopod of maxilla I unjointed. Maxilla II with 3 endites, palp unjointed and scaphognathite possessing 39 setae. Unlike in the postlarva of *M. monoceros* there are no spines on the pereopods. Median dorsal spine present on the 6th abdominal segment. Pleopods uniramous, 3-jointed, distal segment with 10 setae. Spine formula of telson 7 + 7 , posterior margin straight. Distal lateral aspect of 6th abdominal segment possess more than 3 pairs of setae. Larva does not appear browinsh.

Nutrition and growth:- By analysis of the stomach contents of 30 specimens caught during daylight from the Straits of Malacca, Hall (1962) classifies the species in a group feeding mainly on vegetable matter. The items of food in their order of abundance are vegetable matter (mainly angiosperm tissue), small crustaceans (copoepods and ostracods), polychaeta, echiurid setae, molluscan shell pieces and fish remains. Sand grains were present in most of the stomachs. Subrahmanyam (1967) found an omnivorous diet with preference to molluscs as the prawn grows older. Composition of stomach contents of *M. affinis* given by Subrahmanyam (1967) is reproduced below in table XII.

TABLE XII

The compostion of the stomach contents of *M. affinis* (M. Edw.) of different sizes

Length groups (mm.)	106-110	111-115	116-120	121-125	126-130	131-135	136-140	141-145	146-150	151-155	156-160	161-165
Absolute volume of food contents ml.	0.5	0.25	0.25	0.5	0.5	0.22	0.1	0.1	0.25	0.26	0.6	0.15
Food items	%	%	%	%	%	%	%	%	%	%	%	%
Diatoms	..	..	..	..	..	..	..	..	..	8.2	..	..
Algal filaments	12.5	..	..	5.0	13.3	10.5	..	..	..	4.2	..	..
Foraminifera	31.3	..	..	..	13.3	..	..	..	..	16.7	..	..
Nematodes	9.4	20.0	40.0	5.0	1.5	2.5	..	..	..	16.7	..	..
Bivalve shells	6.2	20.0	20.0	60.0	15.0	30.5	..	..	..	33.3	..	..
Gastropod shells	12.3	..	40.0	25.0	30.0	40.0	90.5	100	80.2	..	98.0	80.0
Copepods (remains)	9.4	..	..	..	15.0	3.0	..	..	..	4.2	..	..
Crustacean appendages	0.2	..	..	..	..	5.5	..	..	10.6	12.7	..	10.3
Amphipods (remains)	..	..	..	..	..	2.5	..	..	..	4.0	..	8.2
Debris&sand particles	..	60.0	..	5.0	0.2	5.5	9.5	..	9.2	..	2.0	1.5

In Cochin trawl net catches, in the 1st year classes a growth of 20 mm in males and 25 mm among females in about 6 months time has been recorded by George *et al* (in press). According to Subrahmanyam (1967) in the coastal waters of Calicut juveniles grow up to 115 mm. Males grow up to 105 mm, 135 mm and 155 mm and females up to 115 mm, 155 mm and 175 mm respectively during the first, second and third year of their life, thus showing a differential rate of growth in the sexes, as recorded by several other authors in this as well as other species.

Behaviour and movements:- Juveniles migrate from the sea to back waters and estuaries, but not to the same extent as some other species like *M. dobsoni* and *Penaeus indicus*. In Cochin backwaters juveniles of this species are present in very small numbers in most months. It is probable that most of the postlarvae of this species do not leave the sea.

In the offshore shrimping grounds off Cochin, some movements have been noticed. The species along with some others move to deeper waters during the monsoon period and return after the monsoon. Inshore-offshore migrations of the species in Calicut waters also show more or less the same pattern, moving shoreward from October onwards and back to deeper waters during the monsoon period May-June.

On the east coast of India in Godavari estuary there is more of emigration of the species during night. Intensive migration takes place in April, May and June. Immigration was noticed to be most marked at dawn.

Large concentrations of this species are known to occur in shoals, along with other species, in the mud bank areas off the south west coast.

Reproduction:- *M. affinis* is heterosexual as are all penaeid prawns. External genitalia are petasma in male and thelycum in female (fig. 13b&c). The development of these organs in the species has been described by George and Rao (1967). In addition to the petasma the adult male has other secondary sex characters as in other species.

The minimum length at maturity is 88.6 mm in the late 0-year class. By ova diameter studies and other methods the different maturity stages of the female are classifieds as 'immature', 'early maturing', 'late maturing', 'mature', and spent recovering'. In studies from Bombay waters only 3 stages, namely immature, maturing and mature stages are recorded.

Fecundity estimates show a range between 88,000 to 363,000 eggs. There is a linear logarithmic relationship between the number of eggs and the size of the prawns according to the formula

$$\text{Log } F = - 0.4306 + 2.7179 \text{ Log } L$$

where F is the number of mature eggs and L total length in mm.

The spawning season in Cochin waters extends from October to March with the peak period in November-December. In the Calicut waters the season for spawning is from January to March. In Bombay coast most mature and maturing females are found in October and from April to June. The species has been recorded to spawn more than once during its growth from 91-100 mm to 151-160 mm.

On the south west coast of India in Calicut waters it is observed that the species moves to inshore areas from January to March when most of the females are mature. Along the same coast in Cochin there are indications that it breeds in the 27-45 metre areas. Further north in Bombay it prefers areas of soft mud, rich plankton and shallow coastal waters for mating and spawning.

The most highly developed ovarian eggs measure 0.352 mm according to Rao (1968). He has given measurements of various stages of maturing eggs.

Population and fishery

Sex ratio:- Menon (1957) has described in detail the sex ratio of the species from the inshore catches of the south west coast of India . The sex ratios according to him are shown in Table XIII.

TABLE XIII

Percentage of males in total catch and the same for specimens of over 120 mm.

Year	Total catch	Over 120 mm
1952	52.2	47.2
1953	50.4	47.6
1954	52.0	39.0
1955	44.2	44.2

According to him the population of immature prawns (up to 120 mm) contains similar numbers of each sex. Among older prawns however, there

is considerable disparity, females outnumbering males by 11.6 percent. In Calicut coast (table XIV reproduced from Subrahmanyam, 1967) it is found that females invariably dominate in the catches.

TABLE XIV

Sex ratio of *M. affinis* in various months off Calicut coast during the years 1957-59

	June '57	July	Aug.	Jan. '58	Feb.	Mar.	Apr.	May	June	July	Aug.	Jan. '59	Feb.
Males	47.4	49.9	42.9	46.5	40.0	47.2	43.3	48.4	38.7	43.8	46.4	32.5	47.7
Females	52.6	50.1	57.1	53.5	60.0	52.8	56.7	51.6	61.3	56.2	53.6	67.5	52.3

Statistical analysis of the data on sex ratios of the species in the offshore trawl fishery off Cochin showed that, unlike other co-existing species the two sexes were present in similar numbers throughout the year. Any migration from these grounds must therefore involve similar numbers of each sex. In Bombay waters females occur in more numbers throughout the year, especially during the months of October, November and December.

Age composition:- In the inshore and offshore fisheries off Cochin the species is mostly represented by the 1st and 2nd year classes. In the trawl fishery the 2nd year class generally enters the fishery in the earlier half of the season and the first year class in the latter half. The late 0-year class is also represented in the inshore fishery in some months. In the backwater fishery only 0-year class is represented. Three year groups are present in the fishery at Calicut also. The lengths attained during the three years are 105 mm, 135mm and 155 mm in males and 115 mm and 175 mm in females respectively.

Size composition:- In the inshore fishery of the south west coast of India the prominent length groups are 71-75 mm and 81-85 mm in February to April. In November and December the prominent groups are 121-125 mm and 126-130 mm. In some years the mode reaches 136-140 mm in January or February.

In the trawl fishery, from October to January large sizes, with lengths between 121 and 140 mm are represented in more numbers than in the inshore fishery. Towards the middle of the season, i.e. after February, smaller sizes between 111-115 mm come into the fishery. In the Bombay fishery the species ranged in sizes from 45 mm to 156 mm in length.

In Calicut waters during the period June to August the prawns of this species present in the catches are juveniles measuring below 120 mm, with the modes at 56-60 mm in June and 91-95 mm in August. In other months more than one year class are represented in the collection, in the length range from 31 to 170 mm. Three distinct modal groups are found at 96-100 mm, 141-145 mm and 156-170 mm and these are found to shift in later months.

The sizes at first capture in the backwaters is 30-35 mm as in *M. monoceros*. The maximum size attained in the brackishwaters is about 120 mm and that in deeper waters of the sea nears 180 mm.

Length weight relationship is given by Subrahmanyam (1967) using the measurements of 625 specimens ranging from 31 mm to 176 mm in length. He related weight and total length by the formula

$$W = - 4.6873 + \log L^{2.7867}$$

Based on 183 observations Hall (1962) had given the formula as

$W = 0.7079\ C^{2.770}$ where C is carapace length.

Abundance and density:- Depthwise abundance of the species in the shrimping grounds off Cochin was studied in detail by George *et al*. (1968). There is a general steady increases in abundance in the first half of the season with subsequent decrease. There is considerable decline in abundace of the species in Calicut waters during the months June and July.

Natality and recruitment:- In the inshore fishery of Cochin recruitment of bigger sizes into the fishery commence in October. After December-January the smaller specimens get recruited into the fishery. In the offshore trawl fishery also more or less the same pattern is observed. Recruitment of postlarvae into the backwaters is on a small scale compared to other species.

Fishing areas:- The species is fished particularly on the west coast. Juveniles are fished in small numbers in the backwaters and estuaries including paddy fields of the west coast of India in shallow waters ranging from 1 to 5 metres.

Young adults and adults are caught from depths up to about 55 metres, from the sea. In the trawl fishery off Cochin a concentration of the species is reported in the 18-20 metre depth region. The depth from which it is caught in large numbers from Bombay range from 7 to 13 meters.

Fishing seasons:- The fishery of *M. affinis* tends to be seasonal in all areas where it occurs, but the periods of peak abundance vary in the different fisheries. In the backwater fishery of Cochin the species is most abundant from January to June. The percentage contribution of the species given by Menon & Raman (1961) is shown in Table XV.

TABLE XV

Percentage values (numerical and by weight) of *M. affinis* in the monthly catches in the stake net at Cochin from February 1957 to January 1958

Months	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.
By weight	9.5	10.3	9.9	5.9	12.7	0.5	..	..	2.5	1.4	5.9	13.4
By number	11.4	15.3	15.3	11.4	16.9	2.1	2.1	0.4	1.6	5.2	6.9	15.8

George (1961) gives the percentage contribution of the species in the inshore fishery of the south west coast of India for 1956 through 1960. Its highest percentage is reached in the post monsoon months, November and December, and it is fished from October to May. Subrahmanyam (1967) gives percentages of the species in departmental catches as well as commercial fishery at Cacicut during the years 1957-59, reproduced in Table XVI.

TABLE XVI

Abundace of *M. affinis* in the departmental collections and commercial fishery at Calicut during the years 1957-59.

Year	Month	Departmental collections		Commercial fishery	
		Percentage of prawns	Percentage of *M. affinis*	Percentage of prawns	Percentage of *M. affinis*
1957	January	4.00	1.20	0.10	..
	February	41.52	3.80	0.10	..
	March	43.23	4.60	18.10	..
	April	50.02	6.40	9.53	..
	May	46.67	..	41.65	0.52
	June	..	..	19.47	0.62
	July	60.86	1.40	25.30	1.32
	August	12.85	10.20	0.81	4.56
	September	30.04	..	0.05	..
	October	0.44	..	..	..
	November	15.62	..	..	..
	December	32.83	..	..	..
1958	January	47.05	1.94	0.24	..
	February	28.38	4.49	0.30	0.23
	March	24.37	5.75	2.29	..
	April	37.14	8.11	1.88	..
	May	43.52	2.10	1.16	..
	June	..	..	0.23	2.23
	July	9.77	0.31	17.77	..
	August	7.69	14.36	14.44	..
	September	5.60	..	11.79	..
	October	..	..	0.09	..
	November	0.11	..	0.08	..
	December	2.17	..	..	..
1959	January	3.57	28.57	..	..
	February	12.00	13.99	..	..

The percentage is very low in May to July period.

The peak season for the species in the trawl fishery off Cochin is from December to February. In Bombay waters, although it is available throughout the years, it is most plentiful from January to March. In 1952 to 1954 the species formed 12.3 percent of the Bombay prawn catch. In Calicut inshore waters the fishing season is January to August. On the east coast in the Godavari estuaty, although present most of the years, it is more abundant from November to May.

The inshore fishery of the Kerala intensifies after the annual formation of mud banks on which the prawns concentrate. The fishery in the backwaters of Kerala is probably influenced by rainfall and lunar periodicity. On the Calicut coast there has been found a correlation between bottom salinity and abundance of the species, the fluctuations in the two following a similar pattern. In Godavari estuary also a positive relationship between bottom salinity and abundance of the species was found.

Fishing operation and results:- George (1961), studying the prawn fishery of three centres of the Kerala coast from the years 1956 through 1960, used the total effort and intensity of fishing and established a relationship between catch-per-man-hour and recruit sizes. In the trawl catches of Cochin George *et al*. (in press) studied the effort and intensity of fishing through the years 1958 to 1963 and concluded that there is no overfishing in the area. The catch and effort for one season is shown in Table XVII.

TABLE XVII
Total catch and catch per hour of *M. affinis* in the trawl catches for the season 1959-60

Year	Month	Percentage by weight	Total catch prawns	Total effort in hrs.	Catch of *M.affinis*	Catch per hour for all prawns	Catch per hour for *M.affinis*
1959	November	20.8	2306	301.17	479	8.0	1.6
	December	28.9	10027	430.00	2898	23.0	6.7
1960	January	49.6	22725	491.25	11272	46.0	22.9
	February	28.3	50113	692.68	14182	72.0	20.5
	March	55.8	14119	608.75	7878	23.0	12.9
	April	20.8	18944	660.42	3940	29.0	6.0
	May	29.2	20712	387.33	6048	54.0	15.6

Total catches of prawns including this species for certain regions are given by some authors. Subrahmanyam (1965) gives the total catches of this and other species for new moon and full moon periods in the Godavari estuarine system on the east coast of India. High tide and low tide catches are also given by him.

4. *METAPENAEUS BREVICORNIS* (H. MILNE EDWARDS 1837)

Common names:- In the Gangetic delta area and in Calcutta market it is called '*dhanbone chingri*'. Along Pakistan coast it is known by different names like 'honyi', 'koraney', 'kucho' and 'saga' chingri.

Diagnostic features:- Body not, or very little, tomentose. The rostrum is curved and rarely reaches to the middle of the 2nd joint of the antennular peduncle, sometimes only just surpassing the eyes, with a decided crest and dorsally bearing 7 teeth. The post-rostral crest, however, is very indistinct and only just reaches to the posterior third of the carapace. The antennal spine is weak and not continued as a well-cut post-antennular ridge, so that the post-antennular groove is shallow. The hepatic spine is very small. The sub-hepatic groove (anterior part of cervical groove) which defines the branchial region anteriorly, is shallow and does not meet the hepatic spine. The ridge defining the branchial region superiorly is present only in the posterior part of the carapace, and even there it is indistinct (fig. 15a).

Median carination on abdominal terga present from 4th segment, that of 3rd hardly perceptible and that of 4th only in posterior two-thirds. The 5th abdominal somite about 2/3 length of the 6th, which is as long as the telson. The telson shorter than the inner caudal swimmeret and has no marginal spines. Racek & Dall (1965) observe a pair of clearly perceptible distal spine and a series of minute spinules on the telson.

The outer antennular flagellum is nearly as long as the peduncle.

3rd maxillipeds barely reach the middle of the antennal scale; their dactylus in the male not modified, but consists of a slender, setose, tapering joint about 4/5 length of the propodite with which it articulates end-on.

There is a strong antrorse spine on the basis of all three pairs of chelipeds. Ischial spine present on 1st pereopod. The last pair of

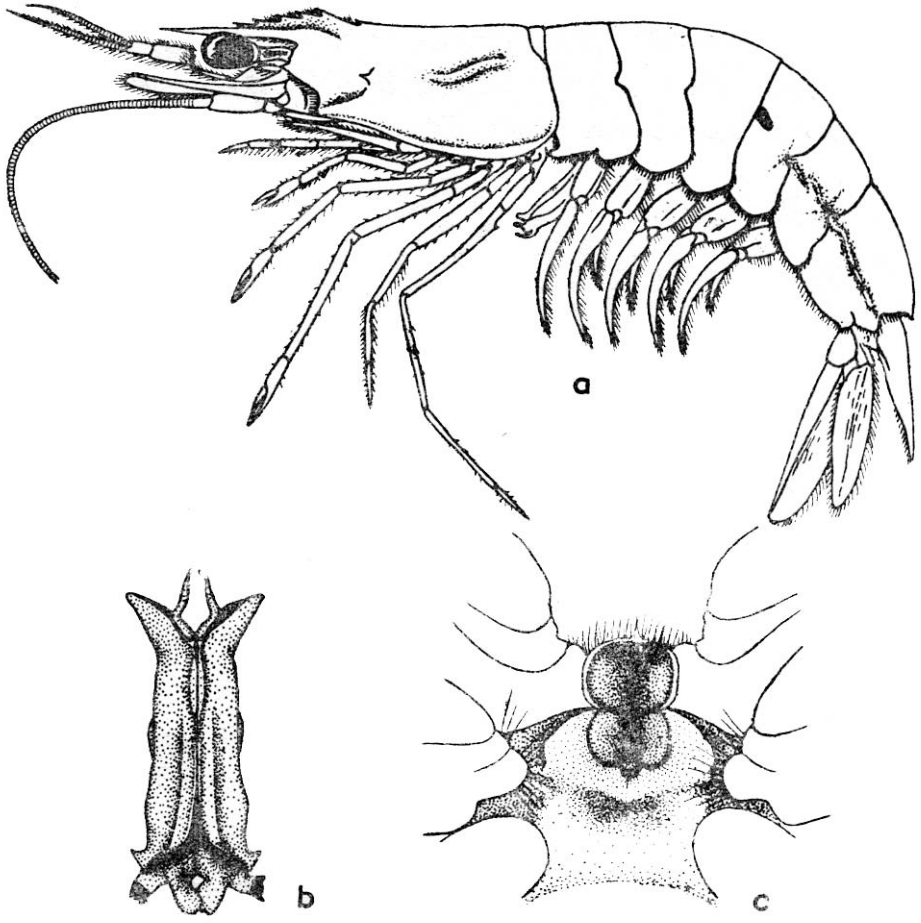


Fig. 15. a. *Metapenaeus brevicornis* (H.M. Edw.); b. Petasma; c. Thelycum.

thoracic legs reach more than a dactylus length beyond the tip of the antennal scale. In the adult male there is notch in the posterior border of the merus at its proximal end, the notch being bounded by a small tooth (not a spine) beyond which there are no denticles; nor is there any subterminal lobe on the border of the ischium.

The petasma is symmetrical and consists of two halves lightly folded in all their length, interlocked all along their anterior margin and in close apposition along a great part of their posterior margin so as to form a compressed tube. Distally this tube ends in a pair of simple spouts, each of which carries near its middle a longish filament (fig. 15b).

The thelycum (fig. 15c) is concave; its median lobe is shaped like a figure of eight, the anterior portion being embraced between processes of the antepenultimate thoracic sternum, the posterior portion being embraced by the flat crescent-shaped lateral lobes.

The species attains a maximum length of about 140 mm.

Body flesh coloured with sparsely distributed brown dots, especially on the dorsal aspect. More such dots on the telson and uropods.

Distribution

General distribution:- The general distribution of the species is West Pakistan through India, Malaysian, Thai and Indonesian waters to about East Borneo. Under the FAO distribution code (Holthuis and Rosa 1965) the distribution in land areas is in 421, 423, 424, 425, 431, 432, 433 and 434. In water areas it has a distribution in the regions ISW and ISEW.

In the distribution of the species in Indian waters one difference noticed from other species like *M. monoceros* and *M. affinis* is that this does not occur in the southern area, but contributes to good fishery in the northern region both on the west as well as east coasts. Well represented in estuaries and inshore waters, especially in the east coast. In estuaries more juveniles are met with. In the Gulf of Kutch area the species is mostly distributed in areas with sandy bottom.

Differential distribution:- There is no information available on the distribution of eggs and larvae. Earlier 0-year group specimens with modal lengths 24.5 mm to 26.5 mm occur in plenty in the catches of the Hooghly estuarine system, more common in July to October period. Only immature prawns are represented in the catches of the upper and middle reaches of the Hooghly estuary. Mature specimens are found in the lower reaches. In Bombay waters even though juveniles and adults are present in the inshore waters throughout the year, mature specimens are very rarely seen.

Life history

Eggs and larvae:- So far there is no report on the larval development of the species.

Nutrition and growth:- Based on the analysis of the stomach contents of 40 specimens of which 23 were from day light fishing operation in Malacca Strait and 17 from night fishing from Singapore prawn pond, Hall (1962) classifieds the species as feeding mainly on vegetable matter. The items of food in the stomachs in their order of abundance are vegetable matter mainly contributed by angeosperm tissue and filamentous algal material, small crustacea mostly contributed by copepods, echiurid setae, large crustacea, remains of fishes like scales etc. and polychaetes. Sand grains were also present in most specimens.

Rajyalakshmi (1961) has worked out the growth pattern of the species in the Hooghly estuaries systems by the probability plot analysis of length frequency distributions. According to her the males and females attain lengths of 45.8 mm and 47.4 mm respectively at the end of the 1st year of life and 80.5 mm and 89.0 mm respectively by the second year of life. Thus the females show a faster growth rate than males during the 2nd year. After the postlarval phase the prawns grow approximately at a rate of 3 mm per month. Specific growth rate is observed to be highest in the young and later declining with age.

She found that in females the growth rate is fastest during summer season when the temperature and salinity of the water in the estuary are high (temperature ranging from 30.45^0 C to 30.82^0 C and salinity 4.3 $^0/_{00}$ to $29.1^0/_{00}$).

TABLE XVIII

Seasonal pattern of growth (females)

Season	Month	Summer brood			Monsoon brood		
		Average modal size mm.	Specific growth (G)	Increment in length	Average modal size mm.	Specific growth (G)	Increment in length
	July	24.5	..	..	..	..	..
Monsoon		..	11.507	14.4	..	..	..
	November	38.9	..	..	26.5	..	..
Winter		..	2.966	4.9	..	6.920	8.4
	March	43.8	..	..	34.95	..	..
Summer		..	7.448	15.2	..	7.8535	12.9
	July	59.0	..	..	47.85	..	..
Monsoon		..	6.015	16.0	..	4.852	10.3
	November	75.05	..	..	58.1	..	..
Winter		..	..	..	..	3.187	7.9
	March	..	..	..	66.0	..	..
Summer		..	..	..	..	..	..
	July	..	..	21.8	..	..	..
Monsoon		..	..	..	..	..	..
	November	96.8	..	..	..	..	..

Growth is medium during rainy season characterised by low salinity and fairly high temperature (temperature 30.0^0 C to 30.80^0C and salinity traces to 9.47 $^0/_{00}$) and low during winter fairly high salinity (1.62 $^0/_{00}$ - 19.78 $^0/_{00}$) and low temperature (21.85^0C to 23.70^0C).

The fluctuations in condition factor of the species was studied by her and she observes moderate fluctuations in 'Kn', more or less cyclic in nature, probably due to weight increase susdequent to moulting.

Behaviour and movements:- In the Hooghly estuary some movements have been traced. Spawning takes place in the marine zone of the estuary or inshore areas and the young one either migrate or get pushed up the

estuary by tidal action, where they live untill the attainment of maturity. Adults appear to migrate back to the lower reaches of the estuary where they mature and spawn.

In Bombay waters it appears that the females are migrating away from the inshore areas towards deeper zones.

Immigration and emigration of the species in and out of the Godavari estuary has also been studied.

Reproduction:- As in the case of other species of penaeids it is heterosexual. Externally visible genitalia and secondary sex characters are present. The size at which the petasmal endopodites fuse in 50% of the specimens is 1.12 cm carapace length as determined by Hall (1962).

Based on the rapid decline and recovery in the condition factor with the attainment of sexual maturity Rajyalakshmi (1961) concludes that the species attains at about 100 mm total length. Bhimachar (1964) records the age at maturity as 2 years and size 75.0 mm.

Females with conjugal pads are present in the inshore waters of Bombay, but mature specimens are absent in the same area indicating that females move to deeper waters for spawning after mating in shallow regions. In Hooghly mature individuals are found to move from the upper reaches to the lower reaches of the estuary for spawning.

In this estuary the species is reported to have two spawning seasons, one in the early summer, namely, March-April and the other in the monsoon months July-August.

Population and fishery

Sex ratio:- In Bombay waters on the west coast of India females are predominant in the catches of throughout the years except in the months January-February. On the east coast in the Hooghly estuary there are more of females in all the months of the year. The ratio of males to females during all the months combined was found to be 1:1.2. The female percentages of these two are given in table XIX.

TABLE XIX
Monthly percentage of females

Place	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Bombay 1952-53 (Shaikmahmud & Tembe, 1960)	49.0	50.0	57.0	67.0	65.0	63.0	57.0	55.0	56.0	58.0	59.0	56.0
Hooghly estuary 1959-60 (Rajyalakshmi, 1961)	61.4	56.0	54.0	56.4	54.0	55.0	51.5	53.8	54.3	52.2	53.7	57.6

Age composition:- Modal lengths of age groups of the species estimated by length-frequency analysis of samples from Hooghly estuarine system given by Rajyalakshmi (1961) are shown in Table XX.

TABLE XX
Modal lengths of different age-groups of *M. brevicornis* as estimated by length-frequency analysis of samples from commercial catches of Hooghly, Matlah and Roopnarain estuaries.

Calendar year	Males					Females				
	0	I		II		0	I		II	
	Monsoon brood	Summer brood	Monsoon brood	Summer brood		Monsoon brood	Summer brood	Monsoon brood	Summer brood	
1959	26.8 ± 3.8	40.0 ± 5.6	54.5 ± 7.3	69.0 ± 4.6	82.0 ± 4.3	24.5 ± 9.1	36.8 ± 4.8	52.1 ± 7.7	71.0 ± 5.6	90.5 ± 6.3
1960	24.8 ± 3.7	37.2 ± 4.6	49.6 ± 5.8	66.0 ± 3.5	79.0 ± 4.97	26.0 ± 2.9	38.0 ± 5.5	52.8 ± 5.3	72.5 ± 4.4	87.5 ± 5.7
Average	25.8	38.6	52.05	67.5	80.5	25.25	37.4	52.45	71.75	89.0

In the lower reaches of upper zone and upper reaches of middle zone of Hooghly estuary I and II year groups from the fishery, the I year class forming the dominant group during all the months except August to October.

In the lower middle zone and lower zone two additional age groups 0 and III also contribute to the fishery, the 0 year group appearing only during the period July to December.

Size composition:- In the Hooghly estuary the catches ranged in size between 15 mm to 115 mm. The length frequency histograms for females and males separately are given by Rajyalakshmi (op. cit.) for the years 1959 and 1960. Males and females measure about 45.8 mm and 47.4 mm respectively by 1 year and 80.5 mm and 89.0 mm by 2 years and these sizes contribute to the fishery in the upper and middle zones of the estuary. The III year group measuring about 90.0 mm also contribute to the fishery in the lower reaches.

In the inshore fishery for the species in Bombay water sizes ranging from 40 mm to 110 mm length are observed.

The length-weight relationship was worked out by Rajyalakshmi (*op. cit.*) for individuals ranging in total length from 23 mm to 120 mm on the basis of 1,968 observations from the Hooghly estuary. She noticed that the relationship between length and weight for the species is linear in the logarithmic form and that the relationship is different for the 0 year group (a) and other individuals (b). The formula for the two groups were :

(a) $\text{Log } W = - 5.0083 + 2.9810 \log L$

(b) $\text{Log } W = - 4.5407 + 2.6976 \log L$

She also studied the relative condition factor 'Kn' which is a ratio between observed and smoothed mean weight (W/W). Seasonal fluctuations and variations in different size groups have been observed in the condition factors and this has been attributed to the nature of growth pattern.

Based on 70 observations Hall (1962) recorded the relationship between carapace length and weight, which is expressed by the formula

$$W = 0.8630\ C^{2.650}$$

Abundance and density:- In the Hooghly estuarine system *M. brevicornis* contributes to over 30.0% of the total prawn catches.

Natality and recruitment:- Based on the availability of smallest modal sizes in the catches the main recruitment season appear to be July-August.

Mortality:- No information available.

Fishing gear:- Bag nets ('bhinjas' and 'thorjals') form the main type of gear with which these prawns are caught in the Hooghly estuarine system. Catches by these nets account for nearly 90% of the total catches. Small drag nets and dip nets account for the rest of the landings. The species is also caught in barrier nets ('kalpat jals'). The 'behundi jal' mentioned by Chopra (1939) is another bagnet or conical purse operated in Bengal in which the species is caught.

Along the Bombay coast the 'dol net' or bag net and a smaller type of the same 'bokshi' are the main gear used for catching the species along with other prawns and fishes.

Fishing boats:- Most of the operations of the above nets are carried out without the help of boats. In operations in which boats are used it is the dug out canoe which are employed.

Fishing areas:- In Bombay waters these prawns are caught from inshore waters varying in depths from 4 to 7 fathoms. In the Hooghly estuarine system they occur in shallow waters.

Fishing season:- July to February is the main season for the species in the Gulf of Kutch area. Slightly south of this area, on the Bombay coast, although the species is found throughout the year, the peak season is from January to March.

In the Hooghly estuarine system it is fished almost round the year. In the lower zone of Hooghly and lower Sunderbans the bulk of the landings is during the winter months of November to February. In the Matlah estuary the fishery commences in August and continues up to March.

According to Rajyalakshmi (*op. cit*.) the trend of occurrence suggests that the bigger sizes are more or less confined to areas of higher salinity. Thus salinity and other hydrographic features of the environment play and important part in influencing the seasonal distribution of the species in the Hooghly estuarine system.

Fishing operation and results:- In Godavari estuary on the east coast Subrahmanyam (1965) gives details of catches of prawns including this species during different lunar phases and also at different tides.

V. GENUS *PARAPENAEOPSIS* ALCOCK 1901

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